Lockheed

MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

SUNNYVALE, CALIFORNIA

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PROCUREMENT SPECIFICATIONS REPORT

IMBLMS PHASE B-4

NAS 9-10742

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

SUNNYVALE, CALIFORNIA

TABLE OF CONTENTS

I. INTRODUCTION

This document contains the Procurement Specifications to provide vendors with supporting information to accurately price the selected major "buy" items. In performing this task, Lockheed was careful to avoid rigid constraints on specifications and drawing details, beyond those necessary to define the basic requirements. It was considered a more meaningful approach to thoroughly acquaint the prospective vendors with the problem at hand and leave him freedom to specify minor design parameters, not critical to equipment requirements, in order to achieve the most effective design at minimum cost, thus, he could best exercise his more intimate and comprehensive knowledge of the product to efficiently satisfy Lockheed's needs. The procedure was as follows:

- The Lockheed Space Systems Division "Make or Buy" Committee selected the several "buy" items detailed in this volume, after recommendations were made by Engineering and the IMBLMS Program Office.
- An exhaustive survey was made by SSD Procurement to determine prospective vendors.
- Vendor candidates were selected and provided the appropriate specifications and drawings.
- Meetings were then held with each prospective vendor, and he was thoroughly briefed on IMBLMS and the requirements for his equipment. Once this close association was established, any additional information needed was provided to ensure accurate pricing.
- Vendors then submitted prices which were reviewed in depth by technical, procurement and Program Office personnel.

II. MAJOR BUY ITEMS

PROCUREMENT SPECIFICATION

DIGITAL PROCESSING EQUIPMENT

1.0 SCOPE

This specification establishes the requirements for a spaceborne general purpose digital computing and mass memory system.

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics

3.1.1.1 Computer Capabilities. The individual IMBLMS flight computers shall be third or fourth generation computers with the following nominal capabilities:

3.1.1.1.1 Word Length - The central processor basic word length for data and instruction words shall be 32 bits. Double precision add, subtract, load, and store are not required but are considered to be desirable features.

3.1.1.1.2 Memory Capacity - The nominal memory capacity shall be 32,000 words, consisting of four 8000 word modules. Optional growth in central memory from 32,000 words to 64,000 words in 8,000 word increments is a required feature. The above capacity requirements define the total memory requirement for the computer configuration.

3.1.1.1.3 Memory Type - The IMBLMS engineering development unit (EDU) will use a destruct-on-readout (DRO) memory with complete read/write addressibility and an 8,000 word module configuration per the previous paragraph. The flight configuration of this same memory will use a mix of non-destruct on readout (NDRO) and DRO memory; both with read/write capability. This mix is defined in terms of 16,000 word memory modules, as follows:

1) Module One -
   12,000 32-bit words of NDRO
   4,000 32-bit words of DRO
2) Module Two -
   11,000 32-bit words of NDRO
   5,000 32-bit words of DRO

Each 16,000 word module shall be provided with multiport capability having a structure of six ports. Each module shall include the logic circuits necessary to make it independent of any other module.

3.1.1.1.4 Data Protection - The content of memory shall not be altered or destroyed by removal or application of primary power to the computer.

3.1.1.1.5 Data Parity - The main storage shall provide for single error detection capability over the entire storage. One parity bit shall be provided for each 32 bit word.

3.1.1.1.6 Operating Speed - The minimum operating speed, as defined by the length of time required for instruction execution, shall be 6 microseconds for Add time and 25 microseconds for Multiply time. These speeds refer to single precision arithmetic, where the speeds are with respect to operands located in SAME MEMORY BANK.

3.1.1.1.7 Central Processor Cycle Time - The maximum acceptable central processor cycle time is 2 microseconds.

3.1.1.1.8 Addressing Capability - The memory shall have complete read/write accessibility to all memory locations, consistent with the requirements in Para. 3.1.1.1.3. This pertains irrespective of whether nondestructive readout or destructive readout are employed. Index registers, all memory addresses, and input/output registers shall be addressable. The instruction formats shall provide for direct specification of the instruction code, indexing options, and an addressing scheme that permits full word as well as partial word (byte) addressing.

3.1.1.1.9 Index or General Registers - A minimum of 6 index or general purpose registers shall be provided; a capability for expanding the number of registers shall be provided.

3.1.1.1.10 Arithmetic Type - Parallel arithmetic shall be used to satisfy speed constraints. The specifications are not fixed with regard to other arithmetic qualities. Hardware floating point shall be provided as an option.

3.1.1.1.11 Instruction Repertoire - The instruction repertoire as listed below, or its equivalent, is a minimum requirement. The instruction set shall be capable of being expanded to satisfy new processing requirements.

MINIMUM INSTRUCTION SET

1. Load arithmetic register
2. Load index register

3. Load I/O register
4. Load Interrupt (mask)
5. Load clock interrupt
6. Store arithmetic register
7. Store index register
8. Store I/O register
9. Store Interrupt (mask)
10. Store clock
11. Fixed point subtract
12. Fixed point add
13. Fixed point multiply
14. Fixed point divide
15. Increment or decrement index register(s) and jump
16. Left shift logical, single
17. Left shift logical, double
18. Right shift algebraic, single
19. Left shift algebraic, double
20. Circular shift, single
21. Circular shift, double
22. Logical AND
23. Logical OR
24. Unconditional jump
25. Store location and jump
26 Jump or skip on discrete
27. Jump or skip index register zero
28. Jump or skip accumulator sign negatives
29. Jump or skip accumulator positive
30. Jump or skip accumulator zero
31. Input instruction(s)
32. Output instruction(s)
33. Enable interrupt (selective)
34. Inhibit interrupt (selective)
35. Jump to specific memory location on interrupt
36. Byte level address
37. Store interval timer

3.1.1.1.12 Clock Frequency - The computer interval clock frequency is selectable by the supplier, but shall be compatible with the timing constraints specified herein. The timing stability of the reference clock shall be $\pm$ 15 ppm (3 sigma value).

3.1.1.1.13 Real Time Clock - A program resettable real time clock shall be provided. Minimum resolution shall be 100 microseconds. Basic clock frequency shall be not less than 500 kHz.

3.1.1.1.14 Interval Timer - A program controlled interval timer with range of 0 to 10 minutes and 1 millisecond resolution shall be provided.

3.1.1.1.15 Special Features - The data processor shall include internal analysis, self-check and fault isolation capabilities under software control to assist in detection of procedural errors and hardware malfunctions or failures.

3.1.1.1.16 Input/Output Section

a) External Indications - The computers shall be capable of providing the operator with a sufficient number of indicators to determine their operating status. These discrete display outputs shall include power on processor; sequence is complete; is computing; is waiting; is stopped; is being dumped; is in standby condition; is loading initial program; is loading executive program; is being powered down; has detected an error; is in operation; has detected an error in data interface. These external indicators shall be made available to the System interface with operator control and display panel via a separate I/O channel. Expansion of these types of indicators shall be possible.

b) Parallel Data Input/Output Registers - A buffered parallel I/O interface of 32 bits plus parity bit shall be provided. Device address lines and status lines shall be provided commensurate with general peripheral requirements. Separate device address lines are required for a minimum of 10 devices. Optional expansion of addressable parallel data channels to up to three in number shall be provided.

c) Data Rate - Peak sustained data rate on one data I/O channel shall not exceed 30,000 32 bit words per second. This shall include 15,000 words/sec input data and 15,000 words/sec output data. Direct memory addressing shall be provided if the above data rate

cannot be sustained in the standard buffered I/O channel(s). Maximum average simultaneous I/O data rate shall be approximately 12,000 words per second.

Average data rates shall be approximately 4000 words per second. Multiple-word data buffers will be incorporated into LMSC-designed external I/O device controllers that will throughput the peak 15,000 word/second data rate. Data chaining techniques that will cause block transfers of data shall be employed in the software design.

d) Interrupts - A minimum of 16 external program interrupt lines are required in addition to the standard internal interrupts; i.e., power fail safe, memory parity failure, real time clock, internal I/O and interval timer. A request on any interrupt line shall force the program to branch to a specified memory location. A priority system of interrupts shall be used.

3.1.1.1.17 Weight, Power and Size - The maximum weight plus power sum for one flight computer shall be 350; weight-power sum of 250 or less shall be the design goal. The weight-power sum includes one IMBLMS Flight Computer (IFC) with 16K central memory, the IFC input/output section and power supply, but does not include the weight of cabling.

The power consumption shall not exceed 200 watts. Maximum weight, per IFC including power supply shall not exceed 150 pounds.

The computer size shall not exceed 1700 cubic inches.

3.1.1.1.18 Input Power - The IFC shall obtain power from a nominal 27.5 ± 2.5 VDC negative grounded power source.

a) Abnormal Input Power - Neither the IFC nor its stored data or power supply shall be damaged when subjected to input voltages varying from 0 to 25.0 VDC, for periods up to 5 minutes.

b) Power Polarity Reversal - Neither the IFC, nor its stored data or power supply shall be damaged when subjected to the range of input voltages as specified in 3.1.1.1.18 of reversed polarity.

c) IFC Voltage Isolation - The IFC shall be capable of withstanding a direct short to any signal carrying line without damage. This includes discrete input/output, input/output registers, or other input/output interface signal interfaces.

3.1.1.1.19 Support Software - In order to perform qualification and acceptance testing, to utilize the IFC AGE and to aid in operational program preparation and debugging, the computer supplier shall provide the following software:

a) Assembler - A FORTRAN or equivalent language program written for a general purpose computer, which assigns absolute addresses to assembly code labels, checks for illegal instructions and syntax, and translates memory instructions into numeric commands.

b) Interpretive Computer Simulation (ICS) - A program in a host computer which emulates the operation of an object computer. Host computer selection should be from an IBM 360 series, UNIVAC 1108, or CDC 6000 series machine.

c) Diagnostic - Assembly language routines to check out IFC shared memory, input/output functions, the complete instruction repertoire, and all interfaces.

d) AGE - Assembly language programs for loading control and for interfacing the IFC with the AGE.

e) Qualification Test - Assembly language routines operated during IFC hardware qualification testing for the purpose of detecting anomalous behavior.

f) Acceptance Test - Assembly language routines operated during hardware acceptance testing for the purpose of verifying computer operability and readiness for use.

g) Library Routines - Assembly level routines having potential use in IMBLMS. All the above programs will be fully documented, including descriptions, flow charts where applicable, program listings, and supplied in a format on a media suitable for direct IFC loading, via paper tape. A magnetic tape capability shall be provided by LMSC.

3.1.1.1.20 AGE - The AGE supportive to operating the IFC during test, checkout, prelaunch, and post-launch processes shall consist of the following components:

a) An alphanumeric keyboard for inserting information into the computer.

b) A control and display unit for

- o displaying the contents of the register or memory word
- o change the contents of any memory word
- o force the computer to execute instructions in "single-cycle" mode.

c) An interface test unit (ITU) for verifying proper operation of the computer input/output. The interface test unit will be used to check out input interrupts, I/O register functioning, sync input/output, and strobes, shift gates, etc. associated with serial data input/output. The ITU shall be used with both computers.

d) Memory loader/output paper tape reader-punch used for bulk loading of memory or recording memory contents.

The AGE shall be designed with regard to human factor engineering requirements with the objective of ease, facility and speed of use. The AGE/computer interface shall be independent of the normal computer I/O interface channels except during the deployment of the interface test unit.

3.1.2 Operability

Per attached General Requirements which apply to all Procurement Specifications.

MASS SPECTROMETER

1.0 SCOPE

This specification establishes the requirements for performance of the Mass Spectrometer used as an element in the Pulmonary System.

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics

3.1.1.1 Primary Performance Characteristics - The Mass Spectrometer shall be similar to that specified by NASA in MSC-01011, 343-334 except that the gas analysis capabilities shall be as shown in 3.1.1.1.1.

3.1.1.1.1 Gas Analysis Capabilities - Inspired or expired gas mixtures shall be simultaneously analyzed for partial pressures of the following gases (range and accuracy to be as tabulated). Response time to 97% shall be less than 0.08 sec. and sample delay time shall be less than 0.2 sec. with a flowrate of 100 ml/minute at STP.

GAS	PARTIAL PRES. RANGE (mm Hg)	MAXIMUM INACCURACY
Oxygen	20 to 775	$\pm$ 2%
Nitrogen	0 to 670	$\pm$ 2%
Carbon Dioxide	0 to 77	$\pm$ 3%
Water Vapor	0 to 50	$\pm$ 3%
C^{12} O^{18}	0 to 3.1	$\pm$ 2%
Helium	0 to 95	$\pm$ 2%

3.1.2 Operability - Per attached General Requirements which apply to all Procurement Specifications.

PROCUREMENT SPECIFICATION

BODY MASS MEASUREMENT DEVICE

1.0 SCOPE

This specification establishes the requirements for the performance of a Body Mass Measurement Device (BMMD).

During prolonged spaceflights, accurate knowledge of an astronaut's mass is important because he is subject not only to the usual causes of gain or loss of weight, but to a number of others as well. Therefore, daily weighing is needed for a continuous assessment of the condition of each astronaut.

This Contract End Item is needed to determine the mass of any astronaut, or of an inanimate object not exceeding man's size and weight. The principle of the device is that a spring-mass system having one degree of freedom will oscillate at a frequency which is a function of the mass. Therefore, by measuring the frequency (or the period) of oscillation of a calibrated spring-mass device, one can determine the mass of the subject, or specimen.

The BMMD shall be similar to the unit described in the following NASA documents.

NASA NO.	TITLE	DATE
MSC-KW-E-69-11	End Item Spec. Flight Hardware for Body Mass Meas. (Experiment M172)	12-12-69
13M12102	AAP Payload Integration-Interface Control Exp. M172, BMM, Flight AAP-2 Electrical Requirement - Prelim.	9-1-69
13M12101	Exp. M172 BMM Device-Flight AAP 2 Mechanical Req'mts. Prelim.	4-1-69

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance - The BMMD shall consist of a seat for the subject which is spring-mounted on a rigidly fixed base. When the seated subject is started into oscillatory motion, a photo cell beam shall be interrupted

by a shutter blade attached to the carriage and picked up by a photo sensitive transistor. The output of the transistor shall be a 5 v 1 ms nominal width pulse train.

3.1.1 Primary Performance Characteristics - The BMMD shall be designed to measure the mass of human subject up to 220 lb. and rigid masses from 50 to 220 lb. in a one-g and in a zero-g environment. The BMMD shall have the requirement of measuring the astronaut mass to an accuracy of ± 1% and rigid masses ± .5%.

Measurements shall be made while the spacecraft is quiescent, (e.g., rotational rate shall not exceed 10 degrees per hour about any axis).

In a one-g artificial gravity environment the BMMD shall be set upon a fixture that permits horizontal leveling. The BMMD shall be mounted upright so that its oscillation vector is perpendicular to the spacecraft's centrifugal vector.

The BMMD will be stowed near the central measurement station. LMSC will provide dimensional interface requirements. Provision shall also be made to rigidly mount the BMMD in its deployed configuration in a location which is convenient for its intended use, and where it can be connected to the IMBLMS Station by an 8-ft. electrical cable.

Provision shall be made to connect a power and signal cable assembly to the BMMD + 28 v DC ($^{+2}_{-4}$ VDC) input power lines and +5 v DC output singnal lines plus a shield are required. Connectors for the BMMD and Cable Assembly shall be interchangeable with that of the Specimen Mass Measurement Device (SMMD).

A cam lock lever, seat release, locking lever, and a release trigger are required. No displays are required.

Removal from launch stowed position, installation in measurement position, and operation shall be accomplished by a single crewmember. Trial operations will be at the discretion of the operator. One hand operation shall be required. A level platform shall be provided for preinstallation checkout of the BMMD and for operation under 1 g artificial gravity.

Five graduated calibration masses are required.

Size stowed:	28 x 22 x 24 in. max.
Size deployed:	36 x 22 x 48 in. max.
Weight:	30 lb.
Power:	4 watts, 28 v DC
Controls:	Cam lock lever
	Seat release
	Locking lever
	Release trigger

Reliability - Per attached General Requirements which apply ... Specifications.

SENSORS

1.0 SCOPE

This specification establishes the requirements for performance and design of sensors to be attached to an astronaut's body for the acquisition of physiologic data. The name sensor applies to bioelectric potential electrodes (ECG, VCG, EEG, EOG, EMG, etc.), impedance electrodes (ZPN, ZCG, etc.), and signal transducers (photo-electric for PWC, piezo-electric for PCG/VbCG, resistive for temperature, etc.). Several different types of sensors are required in each of these major categories; they are described in detail in Table I.

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics - The electrodes and transducers shall be easily applied to the subject, and cause minimal skin irritation. The electrodes shall not require the use of conductive electrode paste, although in certain cases this may be unavoidable to ensure proper signal acquisition.

All electrodes and transducers shall be provided with appropriate leads to establish electrical connection with their respective signal conditioners at the Bio-Belt assembly. All active and ground electrode leads shall include a shock hazard protection system, placed as close to the subject as possible. Transducers which do not make direct electrical contact with the subject, do not require this protection.

The electrodes shall be reusable or disposable; if reusable, they shall require minimum reconditioning time. If skin-penetrating electrodes, such as implantable EMG wire or needle electrodes, are employed, they shall be individually packaged in sterile containers, and shall be able to withstand repeated re-sterilization. All transducers shall be of the re-usable type.

The electrodes and transducers shall be sufficiently durable and have flexible leads, so that they can withstand strenuous exercise by the

subject without signal degradation of lead breakage. Their attachment to the subject shall be such, that motion artifacts are minimized. Following attachment to the subject the electrodes shall be capable of continuous operation for at least 12 consecutive hours without signal degradation.

3.1.1.1 Primary Performance Characteristics - The attached Figures 1 through 6 show the placement of the electrodes and transducers for the measurements identified in Table I.

The ECG, VCG, EEG, EOG, EMG, BSR/GSR, ZPN, and ZCG electrodes establish electrical contact between the subject and the appropriate signal conditioners. The first five types pick up bioelectric potentials directly, whereas the last three types are electrically driven, i.e., they apply either a D.C. or an A.C. carrier signal to the subject and pick up the physiologically induced resistance or impedance changes.

The PCG/VbCG and K sound transducers shall consist of piezoelectric or dynamic microphones, which convert precordial and arterial wall motion into electrical signals.

The PWC transducer consists of a small incandescent bulb (or a light emitting diode) and a photocell in a single package.

The Ear Canal (Body) and Skin Temperature sensors consist of thermistor beads. The ear canal assemblies have the configuration of individually molded plastic hearing-aid type ear inserts.

The heat flux transducers consist of sensitive thermopiles composed of numerous miniature series-connected thermocouples embedded in a flat substrate. In order to reduce the total number of transducers, the skin temperature thermistors are embedded in the same substrate.

All electrodes are used in conjunction with the belt worn signal conditioners and the leads are held in place with anchor buttons. Leads shall be connected to their respective signal conditioners by connectors. Strain relief devices or boots shall be provided to prevent sharp bending of leads where they leave the belt worn package.

3.1.2 Operability - Per attached General Requirements which apply to all Procurement Specifications.

TABLE I

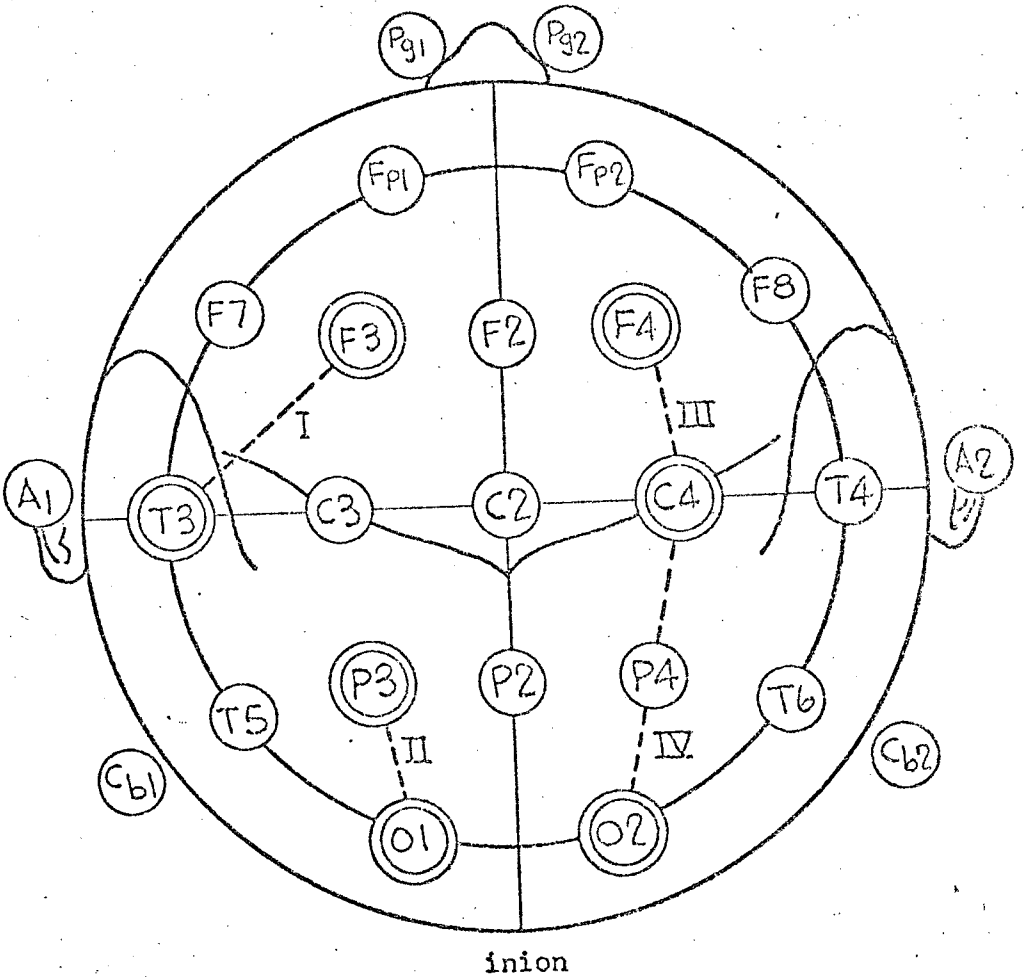
Measurement Group	Item	Type of Measurement	Ref. Figure	Nr. Leads	Type of Electrode
Neuro I	1	EEG	1	2	Sponge, mounted in bathing cap type holder.
	2	EOG	2A	2	Type A. Horizontal placed at outer canthi of eyes.
	3	EMG	2B	2	To be placed as shown in Figure. Type B.
	4	ECG		2	Transthoracic. Type B.
	5	Ground Electrode		1	Mounted on forehead or earlobe. Type B.
Neuro II	6	EEG	1	13	Sponge, mounted in bathing cap type holder. 6 measurements and ground return.
	7	EOG	2A	9	Type A.
	8	EMG		9	Type A and needle and/or implantable wire elect.
Neuro III	9	BSR/GSR		2	(Paste & Electrodes to be developed)
Routine Monitoring	10	EEG	1	5	Sponge, mounted in bathing cap type holder.
	11	ECG		2	Transthoracic. Type B.
	12	ZPN		2	4 inch by 6 inch "plates" of silver impregnated Velcro loop mat'l placed transthoracically.
	13	PCG/V_bCG		2	Precordial microphone with dynamic range 0 to ± 25 MV. Each must have sensitivity matched to within ± 10% over freq. range 0.1 to 1000 Hz.
	14	Ear Temp.		2	Custom molded ear insert containing thermistor.
	15	K Sounds		2	Precordial microphone with dynamic range 0 to ± 30 MV.
	16	PWC	6	3 or 4	Spacelabs Model 404 Photoelectric Pulse Sensor (for finger and toes). Also Infant Sphygmomanometer cuff and pressure transducer (for carotid artery pickup).

TABLE 1 (Cont'd)

Measurement Group	Item	Type of Measurement	Ref. Figure	Nr. Leads	Type of Electrodes
Clinical ECG	17	ECG	3	5	Type B.
	18	ZPN		2	Transthoracic. Type B.
VCG	19	VCG	4	8	Type B.
	20	ZPN		2	Transthoracic. Type B.
	21	PCG/V_bCG			Same as item 13.
	22	Ear Temp			" " " 14.
ZCG	23	ZCG	5	2	Excitation bands. Velcro silver impregnated loop material.
				2	Sensing bands. Same material as above.
	24	ECG			Same as item 4.
	25	PCG/V_bCG			" " " 13.
	26	Ear Temp			" " " 14.
BCG	27	ECG			Same as item 4.
	28	PCG/V_bCG			" " " 13.
	29	ZPN			" " " 11.
Skin Temp. and Heat Flux	30	Avg. Skin Temp		24 pairs	12 pairs for thermistors, 12 pairs for heat flux transducers.
	31	Direct Skin Temp		4 pairs	2 pairs for thermistors, 2 pairs for heat flux transducers.
Clinical EMG	32				Same as item 8.

Note: Type A Electrode -- Miniature EEG type, space qualified.
Type B Electrode -- Equivalent to regular Beckman, EMI, etc., space qualified.

THE TEN-TWENTY ELECTRODE SYSTEM OF THE INTERNATIONAL FEDERATION



A single plane projection of the head, showing all standard positions for EEG electrodes and the location of the Rolandic and Sylvian fissures. The outer circle was drawn at the level of the nasion and inion. The inner circle represents the temporal line of electrodes. The doubly circled electrodes are those most likely to be used for clinical EEG analysis. Position C_3 may be used instead of T_3.

The input for the Frost Sleep Analyzer are usually taken from electrode positions $C_3 - O_1$ or $C_4 - O_2$.

FIGURE 1

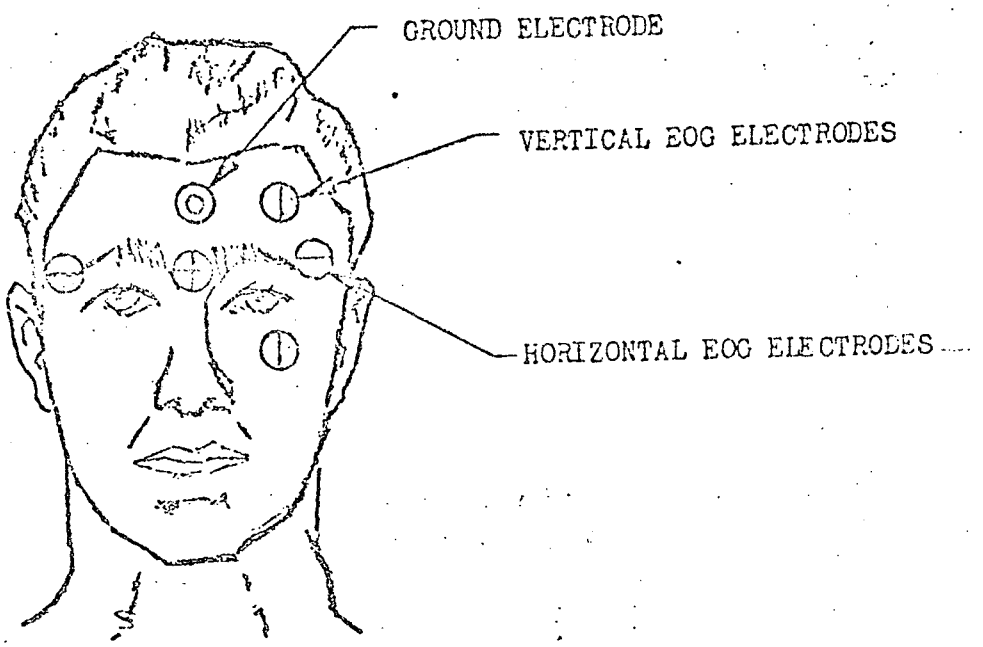


FIGURE 2A

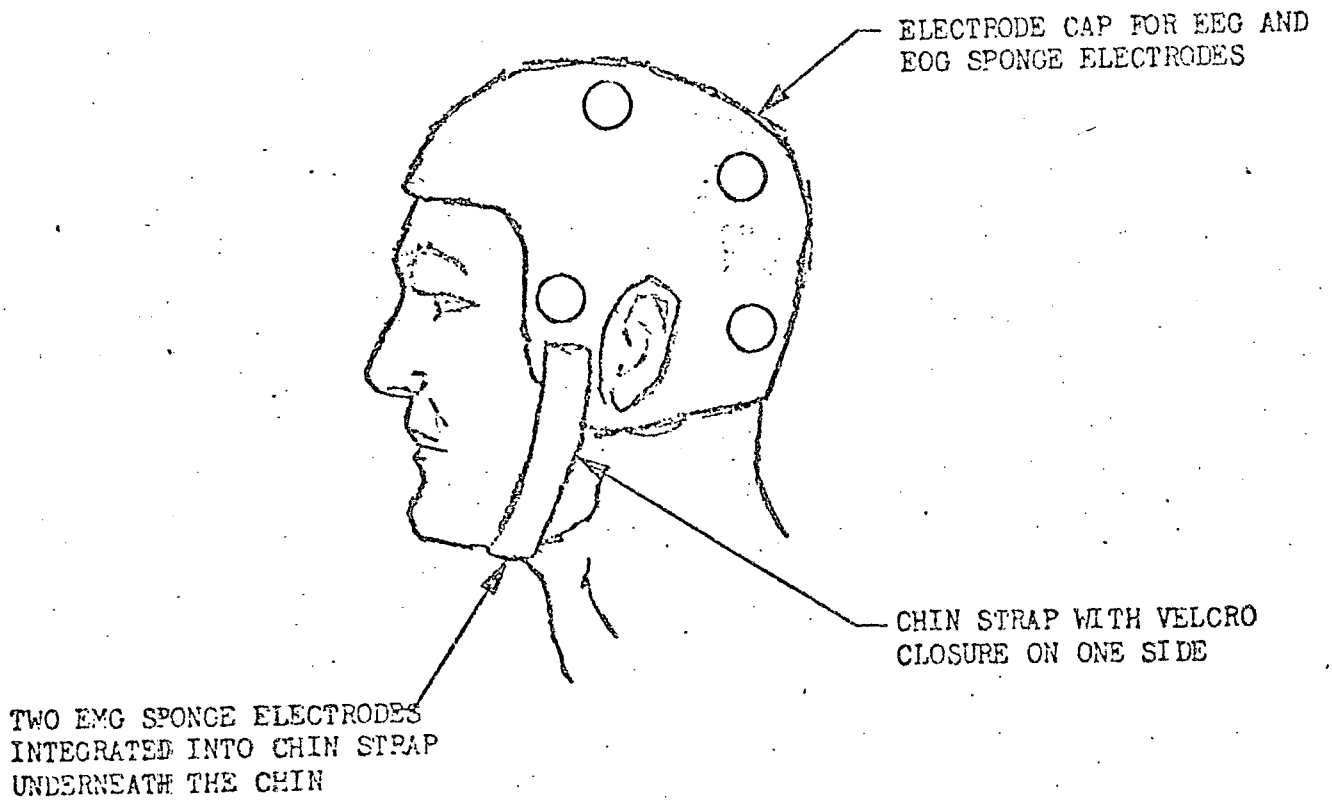
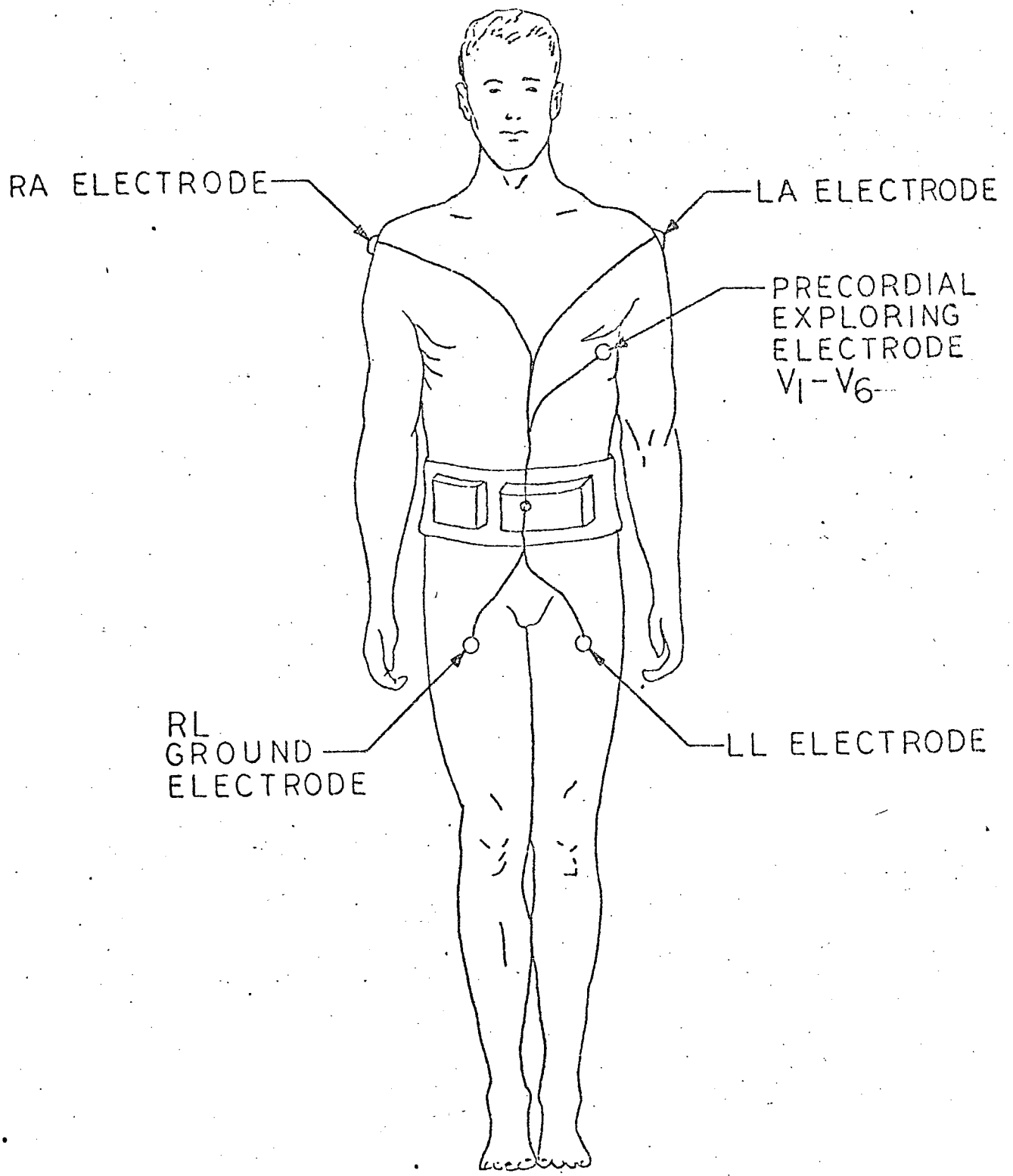


FIGURE 2

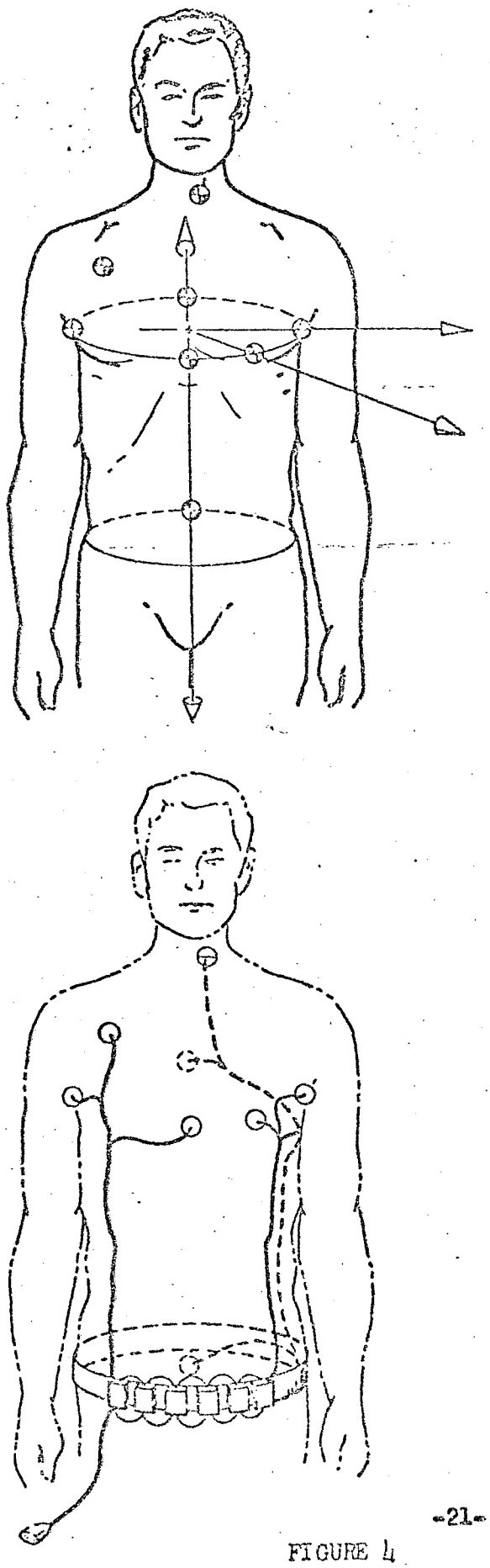


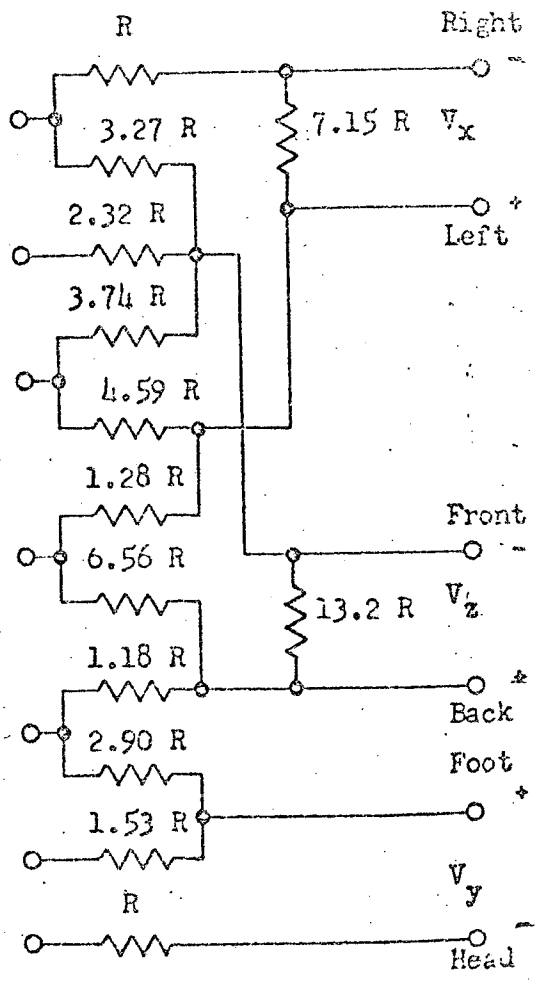
CLINICAL ECG ELECTRODE PLACEMENT

FIGURE 3

VCG Electrode Placement

N - On the back of the neck, one cm to right of midline.
E - On the cardiac dipole level at the front midline.
M - On the back midline at the same level as E.
I - On the right midaxillary line at the same level as E and M.
A - On the left midaxillary line at the same level as E, M, and I.
C - Between front midline and left midaxillary line at 45° and at the same level as E, M, I, and A.
F - At the lower back midline on sacrum.

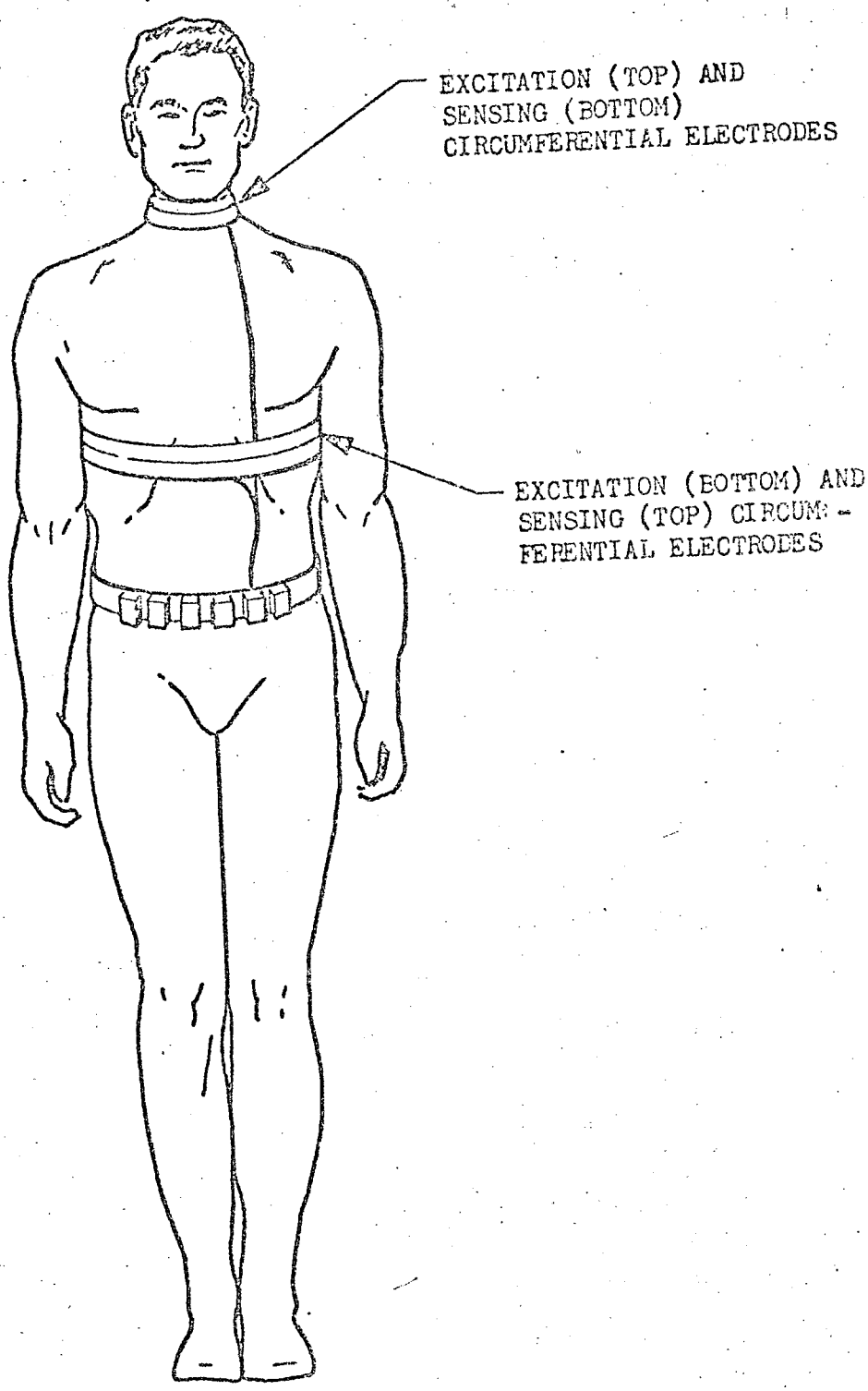




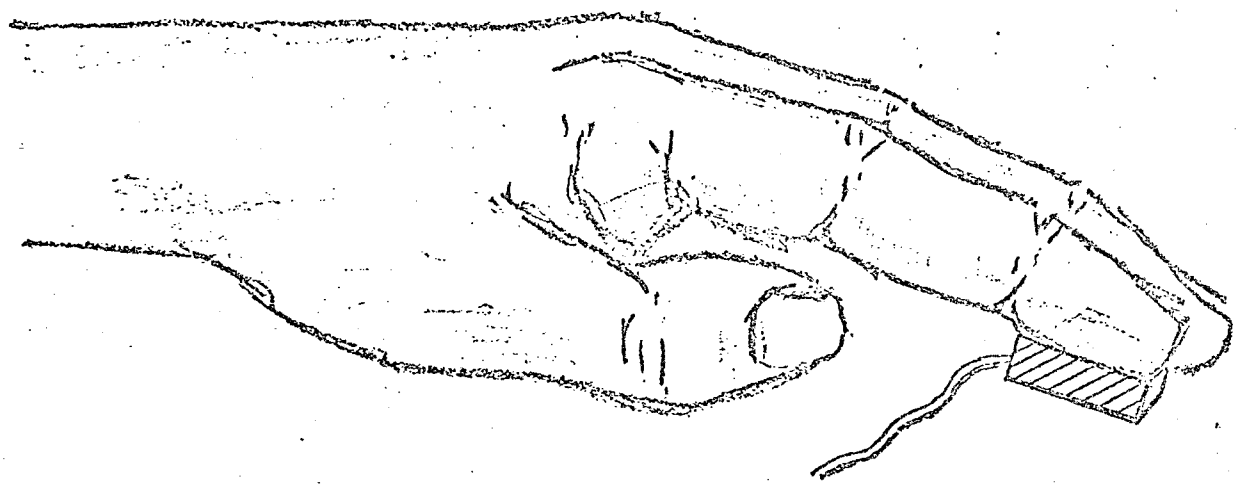
Frank Resistor Network

R = 100K ohms

FIGURE 4



ZCG ELECTRODE PLACEMENT
FIGURE 5



PWC TRANSDUCER ON LEFT FOREFINGER

FIGURE 6

PROCUREMENT SPECIFICATION

BIO-BELT POWER SOURCE

1.0 SCOPE

This specification establishes the requirements for performance and design of one type of equipment identified as a Bio-Belt Power Source. This power source, consisting of a rechargeable battery pack and a d.c. voltage converter, provides power for the instrumentation and electronics contained in a Biomedical Belt.

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics - The Bio-Belt Power Source shall provide the capability for two modes of operation, autonomous and hardline. A Battery Pack shall be used during autonomous operations employing an r-f data link. A DC-DC voltage converter shall replace the Battery Pack as a power source when hardline connections are utilized. The power source system configuration is shown in LMSC drawing 5178058.

3.1.1.1 Primary Performance Characteristics - Required performance characteristics for both the portable, rechargeable, battery pack and the hardline DC-DC voltage converter are defined below. Differences in operating power levels between the two units are primarily due to the fact that the Bio-Belt transmitter and receiver RF elements are not utilized in the hardline operating mode.

3.1.1.1.1 Interchangeability - The DC-DC voltage converter size and power pin connections shall be interchangeable with the battery pack.

3.1.1.1.2 Battery Pack - A composite battery pack shall be employed with all cells connected internally in series and voltage output taps provided for $\pm$ 6 VDC. Table I summarizes the composite battery requirements by sections. The 6 volt (nominal) sections have a higher current capacity in order to accommodate anticipated loads to be placed on the 6 volt taps.

3.1.1.1.3 Type of Cells - Hermetically sealed rechargeable type cells with stainless steel cases are preferred; however, any documented equivalent will be acceptable. Cell material can be, but is not limited to, nickel-cadmium, silver-cadmium, or silver-zinc.

3.1.1.1.4 Battery Pack Size - Shape factor of the Battery Pack is dictated by the fact that it will be placed in the waistband of a body-worn harness. The waistband width is set at 2-1/2 inches therefore the height of the Battery Pack shall be kept within this dimension. The pack shall be contoured to fit the nominal shape of the subject's waist in a horizontal plane. The pack shall be no greater than 2-1/8"H x 2" W x 6" L.

3.1.1.1.5 Battery Pack Weight - The Battery Pack shall not exceed 2.7 pounds in weight.

3.1.1.1.6 DC-DC Converter - The DC-DC converter shall be designed to be interchangeable with the Battery Pack and will be hardlined connected to the central data system. The converter unit shall contain provisions for a Body Ground Lead System (BGLS) for subject safety as well as data input/output connectors, including optical couplers in each line. The BGLS unit and the optical couplers shall not be provided as part of the converter unit. The converter output voltage shall be as defined in Table II.

3.1.1.1.7 DC-DC Converter Weight - The DC-DC converter shall not exceed 3 pounds in weight.

3.1.1.2 Secondary Performance Characteristics

3.1.1.2.1 Isolation - The DC-DC converter shall be designed to provide isolation from high voltages on the external power and ground leads up to 2500 volts.

3.1.1.2.2 Materials - All material shall be non-toxic, non-outgassing, and as low in weight as possible. Suitable plastics may be utilized.

3.1.1.2.3 Useful Life - The unit shall operate within the specified requirements for a period of at least 1000 hours without requiring adjustment or recalibration. It shall be storable for at least one year in a high vacuum.

3.1.1.2.4 Electrical Connectors - Protection shall be provided against reverse polarity and/or improper electrical connections.

3.1.1.2.5 Circuit Protection - Devices for protecting the Bio-Belt electronics from overload conditions shall be provided external to the Bio-Belt Power Source.

3.1.1.2.6 Input Voltage - The DC-DC Converter receives the following input voltage:

+ 27.5 volts $\pm$ 2.5 VDC

3.1.2 Operability - Per attached General Requirements which apply to all Procurement Specifications.

TABLE I

BATTERY - RATINGS - BY SECTION

	BATTERY SECTIONS			
Nominal Voltage	-12.5	-6.25	+6.25	+12.5
Minimum Capacity, Watt-Hr.	5	2.9	13.	25
Minimum Capacity, Amp-Hr.	0.4	0.46	2.1	2.0
Norm. Peak Discharge Rate Amps.	0.2	0.26	0.76	0.7
Norm. Average Discharge - Rate-Amps	0.15	0.21	0.56	0.5
Voltage Regulation (75% Disch.)	± 12% From Nominal			
Minimum Life Expectation	1000 Charge Cycles (with 75% Discharge in 8 Hours)			

TABLE II

CONVERTER PERFORMANCE REQUIREMENTS

PARAMETERS	INPUT/OUTPUT CHARACTERISTICS	
Input Voltage	+ 28 V DC	
Output Voltage	± 12 V. DC	± 6 V. DC
Normal Power Load Peak Av	 3.0 Watts 2.5 Watts	 0.75 Watts 0.5 Watts
Normal Current Load Peak Av	 0.25 Amps. 0.20 Amps.	 0.13 Amps. 0.10 Amps.
Voltage Regulation	± 2% with 50% Overload or 2% Input Change.	
Efficiency - Max. Input Power	Min. 75% 5 Watts @ 56 V. DC.	
Overload Capability	Tolerate Intermittent Current of 100% over rated value for up to 250 Millisec.	
Overload Protection	Automatic circuit interrupt solid state switching to prevent permanent damage if current exceeds 100% over rated value/or 100% over and time exceeds 250 millisec.	
Temperature Effects	Maintain Specified Perform. 60°-80°F Maintain Operation 32 - 125°F	

PROCUREMENT SPECIFICATION

COLORIMETER MODULE

1.0 SCOPE

This part of this specification establishes the requirements for performance of one Colorimeter Module. This item is used to make the following measurements in plasma: alkaline phosphatase, phosphorous, SGOT, SGPT, calcium, bilirubin, and glucose. In urine, phosphorous and calcium are measured. Blood measurements include red blood cell fragility and hemoglobin.

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics

3.1.1.1 Primary Performance Characteristics - The Colorimeter Module shall be capable of performing the required measurements in a zero-gravity environment.

3.1.1.1.1 Wavelength Selections - To perform the required measurements, the following wavelengths shall be provided:

340 nm
415 nm
450 nm
560 nm
575 nm

3.1.1.1.2 Wavelength Interchange - To provide growth capabilities, the design shall permit preselection of other wavelengths.

3.1.1.1.3 Sample/Reagent Containers - The sample and reagent containers shall be designed to prevent contamination of the cabin atmosphere with sample or reagents.

3.1.1.1.3.1 Sample/Reagent Volumes - The sample and reagent containers shall be designed to perform the required measurements with sample volumes from 15 μl to 500 μl, and diluent volumes of 3.4 ml.

3.1.1.1.3.2 Sample/Reagent Container Heaters - The Colorimeter Module shall provide a means of heating and maintaining the sample and reagent containers at 37°C ± 0.25°C.

3.1.1.1.4 Readout - The Colorimeter Module shall be designed to interface with the BCS Data Control Module to provide readouts with the following characteristics:

A. Blood
   1. Hemoglobin in grams per deciliter
   2. RBC Fragility in % salinity

B. Plasma
   1. SGOT in units
   2. SGPT in units
   3. Alkaline phosphatase in units
   4. Bilirubin in milligrams per deciliter
   5. Phosphorous in milligrams per deciliter
   6. Glucose in milligrams per deciliter

C. Urine
   1. Calcium in milligrams per deciliter
   2. Phosphorous in milligrams per deciliter

3.1.1.1.4.1 Readout Range and Accuracy

A. Blood

1. Hemoglobin

Normal	12 to 15 gms/dl	±0.5 gms/dl
Maximum	8 to 20 gms/dl	

2. RBC Fragility 0.24% to 0.50% salinity

B. Plasma

1. SGOT

Normal	20 to 40 units	±10 units
Maximum	20 to 175 units	

2. SGPT

Normal	20 to 40 units	±10 units
Maximum	20 to 175 units	

3. Alkaline Phosphatase

Normal	30 to 55 units	±11 units
Maximum	20 to 300 units	

B. Plasma (continued)

4. Bilirubin		
Normal	0 to 1.0 mg/dl	±0.1 mg/dl
Maximum	0 to 20 mg/dl	
5. Phosphorous		
Normal	2.5 to 4.5 mg/dl	±0.3 mg/dl
Maximum	0.4 to 8 mg/dl	
6. Glucose		
Normal	65 to 105 mg/dl	±5 mg/dl
Maximum	40 to 200 mg/dl	

C. Urine

1. Calcium		
Normal	10 to 30 mg/dl	±1 mg/dl
Maximum	12 to 30 mg/l	
2. Phosphorous		
Normal	20 to 80 mg/dl	±2 mg/dl
Maximum	0 to 100 mg/dl	

3.1.1.1.5 Calibration - Calibration samples shall be used to standardize the colorimeter before each series of measurements.

3.1.1.2 Secondary Performance Characteristics - The BCS shall provide the proper mounting and support structure to support the Colorimeter Module with the following characteristics:

Height	8-1/2 inches
Width	8-1/2 inches
Depth	6 inches
Weight	11 pounds (including 4 bag holders)

The sample/reagent bags shall be designed such that the risk of contamination of the cabin atmosphere by sample or reagent is reduced to an absolute minimum.

The Colorimeter Module waste will consist of plastic reagent/sample bags containing approximately 3.5 ml liquid. Number of bags shall be determined by the frequency of experiments.

The Colorimeter Module shall operate within the following power consumption limits:

Colorimeter:

Average Power	Not Applicable
Peak Power	3.5 watts
Standby	3.2 watts

Sample/Reagent Bag Heaters:

Average Power	Not Applicable
Peak Power	50 watts
Standby Power	0.5 watts

The Colorimeter Module will require 27.5 V dc.

There shall be sufficient data lines to provide usable outputs to the Data Management Module with the following characteristics:

1.	Rate:	Continuous
2.	Format:	Three analog; one 3-bit digital
3.	Level:	Analog 0 to +5 V dc; digital TTL compatible

3.1.1.2.1 Wavelength Selector - The Colorimeter Module shall be designed to allow the operator to select one of five filters to be inserted into the optical path by manually operating a selector knob.

3.1.1.2.2 Sample/Reagent Containers - The sample/regent containers shall be made from plastic film of good optical quality and suitable chemical resistance. These plastic bags shall be completely sealed to prevent contamination of the cabin atmosphere. The necessary reagents shall be sealed into the containers and additions of the sample and diluting solutions shall be through a septum which shall be an integral part of the bag. The septum arrangement shall be designed to interface with the Diluter on the BCS Service Module.

3.1.1.2.2.1 Sample/Reagent Bag Configuration - The sample/reagent bags shall be formed with at least two compartments separated by a flow-through restriction. One compartment shall be considered the optical compartment and shall be sized to provide flat and parallel optical surfaces of not less than 0.6 cm in diameter with a path length of 0.7 cm. This shall be accomplished with approximately 3.4 ml of solution suitably confined in the optical compartment. The second compartment shall be sized such that bubbles can be manually kneaded or otherwise expressed from the optical compartment into the second compartment. The restriction between the

compartments shall be sized such that return of the bubbles to the optical compartment is prevented. The restriction must allow free flow of liquids (during manipulation) to provide good reagent-sample mixing.

3.1.1.2.2.2 Sample/Reagent Bag Holder - The sample/reagent bag holder shall be designed to make the filled sample/reagent bag conform to the required optical path length and optical surface. The holder shall be designed to position the optical portion of the sample/reagent bag in the optical path of the Colorimeter Module.

3.1.1.2.2.2.1 Temperature Control - The sample/reagent bag holder shall be designed to provide controlled heat to the bags when required. The temperature shall be 37° ±0.25°C.

3.1.2 Operability - Per attached General Requirements which apply to all Procurement Specifications.

PROCUREMENT SPECIFICATION

CENTRIFUGE MODULE

1.0 SCOPE

This specification establishes the requirements for performance of one Centrifuge Module. This item is used to separate formed elements of blood.

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics

3.1.1.1 Primary Performance Characteristics - The Centrifuge Module shall be capable of separating the formed elements of blood in a zero-gravity environment. The BCS shall provide the proper mounting and support structure to support the Centrifuge Module with the following characteristics:

Size:	18 in. x 18 in. x 6 in.
Weight:	9.6 pounds

The Centrifuge shall operate within the following power consumption limits:

Average Power	40 watts
Peak Power	70 watts during run-up
Standby Power	None

The Centrifuge Module will require 27.5 V dc.

3.1.1.1.1 Rotor - The rotor shall have the capacity to spin six 10 to 12 ml samples at a relative centrifugal force of 2500 to 5000 g.

3.1.1.1.2 Speed Control - The Centrifuge Module shall contain a speed control and indicator to adjust the RFC between the ranges 2500 to 5000 g.

3.1.1.1.3 Safety Interlock - The Centrifuge Module shall be designed such that the access door to the rotor cannot be opened when the rotor is moving at a potentially dangerous speed.

3.1.2 Operability - Per attached General Requirements which apply to all Procurement Specifications.

ELECTRONIC HEMATOCRIT MODULE

1.0 SCOPE

This specification established the requirements for performance of one Electronic Hematocrit Module. This item is used to measure the relative volume of the red blood cells (erythrocytes) in whole blood.

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics

3.1.1.1 Primary Performance Characteristics - The Electronic Hematocrit Module shall be capable of measuring the relative volume of the red blood cells in whole blood while in a zero-gravity environment.

3.1.1.1.1 Sample Volume - The total sample volume required for the measurement shall not exceed 0.5 ml.

3.1.1.1.2 Sample Handling - The sample injection and waste collection shall be designed such that the risk of contamination of the cabin atmosphere with the blood sample during transfer of measurement is reduced to an absolute minimum.

3.1.1.1.3 Readout - The Electronic Hematocrit Module shall be designed to interface with the BCS Data Management Module to provide a direct readout in percent hematocrit.

3.1.1.1.3.1 Readout Range and Accuracy - The dynamic range shall be between 20 to 60 percent hematocrit with an accuracy of $\pm$ 2 percent of reading.

3.1.1.1.4 Calibration - The Electronic Hematocrit Module shall be provided with an automatic internal standardization.

3.1.1.2 Secondary Performance Characteristics - The BCS shall provide the proper mounting and support structure to support the Electronic Hematocrit Module with the following characteristics:

Size:

Height	4-1/4 inches
Width	4-1/4 inches
Depth	2-1/2 inches
Weight:	0.6 pounds

The Electronic Hematocrit Module shall be provided with a liquid waste collection system which will not contaminate the cabin atmosphere.

The Electronic Hematocrit waste will consist of 100 ml plastic bags filled with a mixture of blood and rinse water. The number of bags will be determined by the number of measurements made.

The Electronic Hematocrit Module shall operate within the following power consumption limits:

Average Power	Not Applicable
Peak Power	2.0 watts
Standby Power	1.6 watts

The Electronic Hematocrit Module will require 27.5 V dc.

There shall be sufficient data lines to provide usable outputs to the Data Management Module with the following characteristics:

Rate:	Upon command
Format:	Analog
Level:	0 to + 5 V dc

3.1.1.2.1 Method of Measurement - The method of measurement for the Electronic Hematocrit Module shall be by a measurement of the conductivity of a fixed volume and path length of whole blood.

3.1.1.2.2 Sample Cell - The sample cell shall be arranged such that positive determination can be made that the cell is completely filled between the electrodes.

3.1.1.2.3 Sample Handling

3.1.1.2.3.1 Sample Injection - The sample shall be injected by a manually operated syringe. The sample port shall be a standard Luer-Loc fitting.

3.1.1.2.3.2 Waste Disposal - All sample and rinse solutions shall be collected in a disposable plastic bag. The plastic bag shall contain a check valve to prevent spillage during disconnect and disposal.

3.1.1.2.3.3 Sample Isolation - The fluid system shall be designed such that the sample and liquid waste will not make electrical contact with any component other than the measuring electrodes during the time a measurement is being made.

3.1.2 Operability - Per attached General Requirements which apply to all Procurement Specifications.

PROCUREMENT SPECIFICATION

BLOOD GAS, pH AND ELECTROLYTES MODULE

1.0 SCOPE

This specification established the requirements for performance of one Blood Gas, pH and Electrolytes Module. This item is used to make the following measurements in blood: pH, pCO_2, and pO_2. In plasma, calcium, chloride, potassium and sodium are measured. In urine, chloride, potassium, sodium and pH are measured.

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics

3.1.1.1 Primary Performance Characteristics - The Blood Gas, pH and Electrolytes Module shall be capable of performing the required measurements in a zero-gravity environment without contamination of the cabin atmosphere.

3.1.1.1.1 Sample Volume - The total sample volume required for measurement of blood pH, pCO_2, and pO_2 shall not exceed 1.0 ml. The total sample volume required for the measurement of calcium, chloride, potassium, sodium and pH in plasma or urine shall not exceed 0.75 ml.

3.1.1.1.2 Sample Handling - The sample injection and waste collection shall be designed such that the risk of contamination of the cabin atmosphere with the blood, plasma or urine sample during transfer or measurement is reduced to an absolute minimum.

3.1.1.1.3 Readout - The Blood Gas, pH and Electrolytes Module shall be designed to interface with the BCS Data Control Module to provide readouts with the following characteristics:

A. Blood

1. Partial pressure of O_2 in millimeters of mercury
2. Partial pressure of CO_2 in millimeters of mercury
3. Hydrogen ion activity in pH units

B. Plasma

1. Calcium ion activity in mg/dl
2. Chloride ion activity in meq/l
3. Potassium ion activity in meq/l
4. Sodium ion activity in meq/l

C. Urine

1. Chloride ion activity in meq/l
2. Potassium ion activity in meq/l
3. Sodium ion activity in meq/l
4. Hydrogen ion activity in pH units

3.1.1.1.3.1 Readout Range and Accuracy - The Blood Gas, pH, and Electrolytes Module shall be designed to provide readouts with the following ranges and accuracies to the BCS Data Management Module:

A. Blood

1.	pO_2	MAX:	20 to 50 mm $\pm$ 2 mm
		NORM:	25 to 40 mm $\pm$ 2 mm
2.	pCO_2	MAX:	20 to 70 mm $\pm$ 2 mm
		NORM:	31 to 45 mm $\pm$ 2 mm
3.	pH	MAX:	7.00 to 7.60 $\pm$ 0.02
		NORM:	7.35 to 7.45 $\pm$ 0.02

B. Plasma

1.	Calcium	MAX:	7 to 12 mg/dl
		NORM:	9 to 11 mg/dl
2.	Sodium	MAX:	120 to 160 meq/l $\pm$ 2 meq/l
		NORM:	135 to 145 meq/l $\pm$ 2 meq/l
3.	Potassium	MAX:	2 to 7 meq/l $\pm$ 0.3 meq/l
		NORM:	3.5 to 5 meq/l $\pm$ 0.3 meq/l
4.	Chloride	MAX:	80 to 120 meq/l $\pm$ 3 meq/l
		NORM:	100 to 110 meq/l $\pm$ 3 meq/l

C. Urine

1.	Sodium	0 to 200 meq/l $\pm$ 3 meq/l
2.	Potassium	20 to 200 meq/l $\pm$ 2.2 meq/l
3.	Chloride	50 to 200 meq/l $\pm$ 5 meq/l
4.	pH	5 to 9 pH units $\pm$ 0.1 pH units

3.1.1.1.4 Calibration

3.1.1.1.4.1 Electrolytes - The Blood Gas, pH, and Electrolytes Module shall provide a means of injecting solutions representing high and low calcium, sodium, potassium, and chloride ion concentrations for calibration.

3.1.1.1.4.2 pH - The Blood Gas, pH, and Electrolytes Module shall provide a means of injecting solutions representing high and low pH values for calibration.

3.1.1.1.4.3 pO_2 and pCO_2 - The Blood Gas, pH, and Electrolytes Module shall provide a means of supplying gas mixtures representing high and low concentrations of O_2 and CO_2 for calibration.

3.1.1.2 Secondary Performance Characteristics - The BCS shall provide the proper mounting to support the Blood Gas, pH, and Electrolytes Module with the following characteristics:

Size:	
Height	9-1/1 inches
Width	9-1/2 inches
Depth	18 inches
Weight:	17 pounds

The entire module shall be rail-mounted to allow the module to be withdrawn at least 10 inches from the support structure to provide access to the electrode block for routine electrode maintenance.

The Blood Gas, pH, and Electrolytes Module shall operate within the following power consumption limits:

Average Power	Not Applicable
Peak Power	55 watts
Standby Power	7.5 watts

The Blood Gas, pH, and Electrolytes Module will require 27.5 V dc.

There shall be sufficient data lines to provide usable outputs to the Data Management Module with the following characteristics:

Rate:	Continuous
Format:	8 analog
Level:	0 to + 5 V dc

3.1.1.2.1 Measurement Method - The method of measurement shall be by potentiometric and polarographic electrodes.

3.1.1.2.2 Electrode Blocks - The electrodes shall be mounted in two separate electrode blocks. One electrode block shall contain a sample system for blood pO_2, pCO_2, and pH, and the other electrode block shall contain a sample system for calcium, pH, sodium, potassium, and chloride of plasma and urine.

3.1.1.2.3 Thermal Control - During calibration and measurement, the Blood Gas and pH electrode block and associated preheater shall be maintained at 37°C ± 1°C. The design shall provide for maximum transfer of heat from the block to the sample being measured.

3.1.1.2.3.1 Sample Conditioning - The design shall provide for a means of preheating only the Blood Gas and pH sample to minimize the time to thermally equilibrate once the sample is in the electrode block.

3.1.1.2.3.2 Calibration Liquids - The design shall provide for a means of preheating only the calibration pH liquids to minimize the time to thermally equilibrate once the liquid is in the electrode block.

3.1.1.2.3.3 Calibration Gases - The design shall provide a means of heating the gases to 37°C ± 0.1°C.

3.1.1.2.4 Sample Injection - The sample shall be manually injected by a syringe which will interface with the front panel sample inlet port.

3.1.1.2.5 Calibration Solution Injection - The correct amount (approximately 1.5 ml) of each calibration solution shall be automatically pumped through the electrode block.

3.1.1.2.5.1 Rinse Solutions - Rinse solutions shall be manually injected by a syringe or from the Service Module pump.

3.1.1.2.6 Selector Valve - The various calibration, rinsing, and sampling cycles shall be automatically or manually controlled by a front-panel selector valve.

3.1.1.2.6.1 Position Indicator - A position indicator connected to the selector valve will automatically indicate the functional mode.

3.1.1.2.7 Waste Disposal - All sample, rinse, and calibration liquids from each sample system shall be collected in a separate disposable waste container. The waste containers shall contain a check valve to prevent spillage during disconnect and disposal. A positive means of indicating when the waste container is full shall be provided.

3.1.1.2.8 Sample Isolation - Each fluid system shall be designed such that the sample calibration and waste liquids will not make electrical contact with any component other than the measuring electrodes during the time a measurement is being made.

3.1.2 Operability - Per attached General Requirements which apply to all Procurement Specifications.

PROCUREMENT SPECIFICATION

ELECTRONIC BLOOD CELL COUNTER MODULE

1.0 SCOPE

This specification establishes the requirements for performance of one Electronic Blood Cell Counter Module. This item is used to count red blood cells to determine the number of erythrocytes in a known volume of blood, and to count white blood cells to determine the number of leucocytes in a known volume of blood.

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics

3.1.1.1 Primary Performance Characteristics - The Blood Cell Counter shall be capable of performing the required measurements in a zero-gravity environment.

3.1.1.1.1 Sample Handling - The sample injection and waste collection system shall be designed such that the risk of contamination of the cabin atmosphere with the sample is reduced to an absolute minimum.

3.1.1.1.2 Sample Volume - The counter shall count the number of red blood cells or white blood cells in approximately a 1 ml volume of a total 3 to 4 ml available sample.

3.1.1.1.3 Readout - The Blood Cell Counter Module shall be designed to interface with the BCS Data Control Module to provide readouts with the following characteristics:

A. White blood cells in thousands of cells per mm^3.

B. Red blood cells in millions of cells per mm^3.

3.1.1.1.3.1 Readout Range and Accuracy -

A. White blood cells 2 to 20 thousand $\pm$ 4 percent.

MAX: 2 to 20 thousand/mm^3

NORM: 5 to 10 thousand/mm^3 $\pm$ 4 percent

B. Red blood cells 2 to 7 million $\pm$ 4 percent.

MAX: 2 to 7 million/mm^3

NORM: 4.5 to 6.5 million/mm^3 $\pm$ 4 percent

3.1.1.1.4 Calibration - Not required.

3.1.1.2 Secondary Performance Characteristics - The BCS shall provide the proper mounting to support the Blood Cell Counter Module with the following characteristics:

Size:	
Height	4-1/4 inches
Width	8-1/2 inches
Depth	8-1/2 inches
Weight:	2.7 pounds

The Blood Cell Counter Module shall be provided with a liquid waste collection system which will not contaminate the atmosphere.

The Electronic Blood Cell Counter Module shall require (TBD) of normal saline solution. This solution shall be stored and dispensed by the Service Module.

Status of the liquid waste from the Blood Cell Counter Module TBD.

The waste from the Blood Cell Counter Module will consist of one 3.5 ml WBC plastic container and one 3.5 ml RBC plastic container, both filled with blood diluted with saline. The number of bags will be determined by the frequency of measurement.

The Blood Cell Counter Module shall operate within the following power consumption limits:

Average Power	Not Applicable
Peak Power	7.6 watts
Standby Power	1.5 watts

The Blood Cell Counter Module will require 27.5 V dc.

There shall be sufficient data lines to provide usable outputs to the Data Management Module with the following characteristics:

1.	Rate:	Once when accessed
2.	Format:	10 bits parallel
3.	Level:	TTL compatible

3.1.1.2.1 Measurement Method - The method of measurement shall be based on the measurement of impedance changes as cells traverse a narrow orifice.

3.1.1.2.2 Sample System

3.1.1.2.2.1 Sample Containers - The diluted samples for the WBC and RBC counts shall be contained in 3.5 to 4 ml flexible containers. The sample and diluent shall be injected through a septum. The flexible containers shall be

designed to provide a means of shaking or kneading bubbles out of the main container into a bubble trap. The WBC container shall contail a suitable quantity of a lysing reagent. This reagent shall be isolated from the sample until the operator manually releases the reagent into the sample.

3.1.1.2.2.2 Sample Flow - The sample shall be drawn through the orifice from a closed, flexible container by a motor-driven positive displacement piston. Entry into the closed, flexible container shall be by a needle on the module through a septum in the flexible container.

3.1.1.2.2.3 Sample Rate - The sample shall be drawn through the orifice at approximately 1/2 to 1 ml per minute.

3.1.1.2.3 Orifice - The orifice size shall be 100μ diameter and approximately 100μ in length.

3.1.1.2.4 Counting Period - The counting time shall be determined by the position and travel of the piston. The piston shall draw approximately 1/2 ml of sample, start the count automatically, maintain the count while drawing 1 ml, stop the count automatically. The piston shall then return the sample container.

3.1.1.2.5 Waste Collection - The sample drawn into the piston will be returned to the sample bag for disposal.

3.1.1.2.6 Fault Indication - The design shall provide a positive fault indication in the event that a bubble passes through the orifice and produces spurious counts.

3.1.2 Operability - Per attached General Requirements which apply to all Procurement Specifications.

SOLID WASTE MODULE

1.0 SCOPE

This specification establishes the requirements for performance of one Solid Waste Module. This module is used to collect and retain the solid waste products from a series of experiments.

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics

3.1.1.1 Primary Performance Characteristics - The Solid Waste Module shall be capable of retaining the solid waste (until disposed) in a zero-gravity environment. The BCS shall provide the proper mounting and support structure to support the Solid Waste Module with the following characteristics:

Size:	
Height	4-1/2 inches
Width	8-1/2 inches
Depth	17 inches
Weight:	1.7 pounds

3.1.1.1.1 Waste Retainer - The entrance door shall be designed such that solid objects can be inserted without spillage of existing waste. This shall be accomplished with the use of one hand.

3.1.1.1.2 Waste Container - The Solid Waste Container shall be of rigid construction with the waste materials collected in a flexible liner. The design shall allow the flexible liner to be removed for disposal without spillage of the contents.

3.1.1.1.2 Liner Volume - The disposable liner shall have a useable volume of up to 500 cubic inches.

3.1.2 Operability - Per attached General Requirements which apply to all Procurement Specifications.

PROCUREMENT SPECIFICATION

SUPPLIES STOWAGE MODULE

1.0 SCOPE

This part of this specification established the requirements for performance of one Supplies Stowage Module. This item is used to contain the kits and supplies to support the measurements made on the Bio-Chemical Station.

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics

3.1.1.1 Primary Performance Characteristics - The Supplies Stowage Module shall contain and make readily available the various supplies required to perform the Bio-Chemical Station measurements in a zero-gravity environment. The BCS shall provide the proper mounting and support structure to support the Supplies Stowage Module with the following characteristics:

Height	8-1/2 inches
Width	8-1/2 inches
Depth	17 inches
Weight	TBD

3.1.1.1.1 Contents - The definition of the contents of individual items and content of measurement kits TBD.

3.1.2 Operability - Per attached General Requirements which apply to all Procurement Specifications.

PROCUREMENT SPECIFICATION

SLIDE STAINER MODULE

1.0 SCOPE

This specification establishes the requirements for performance of one Slide Stainer Module to impart a distinctive color to the various formed elements of the blood to facilitate visual recognition of the various cell types and also to impart a color to various microbiological organisms to permit distinction of the morphologic characteristics of the organism.

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics

3.1.1.1 Primary Performance Characteristics - The Slide Stainer Module shall be designed to perform the required slide stainer operations in a zero-gravity environment without contamination of the cabin atmosphere. The Bio-Chemical Station shall provide the proper mounting and support structure to support the Slide Stainer Module with the following characteristics:

Length	4-1/2 inches
Width	4-1/2 inches
Depth	2-1/1 inches
Weight	0.7 pounds

3.1.1.2 Secondary Performance Characteristics

3.1.1.2.1 Slide Holder - The slide holder shall be designed to confine the slide in such a manner as to allow reagents and rinse solutions to pass over the area to be stained without escaping to the cabin atmosphere.

3.1.1.2.1.1 Visual Indication - The slide shall be mounted to allow visual indication that the various stains have covered the area of interest, and that the stains have been adequately flushed before the slide is removed.

3.1.1.2.2 Liquid Handling - The various stains shall be injected into the slide holder through a female Luer-Lok fitting on the front panel.

3.1.1.2.2.1 Liquid Waste - The liquid waste from the staining procedure shall be collected in a disposable plastic container. This container shall be located to give visual indication when replacement is required. The container shall have a check valve to prevent the contents from spilling during disposal.

3.1.2 Operability - Per attached General Requirements which apply to all Procurement Specifications.

PROCUREMENT SPECIFICATION

SERVICE MODULE

1.0 SCOPE

This part of this specification establishes the requirements for performance of one Service Module. This Module provides sample preparation, sample handling, and clean-up functions for other modules.

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics

3.1.1.1 Primary Performance Characteristics - The Service Module shall be capable of providing the required support functions in zero-gravity environment. The BCS structure shall provide the proper mounting and support structure to support the Service Module with the following characteristics:

Length	8-1/2 inches
Width	4-1/2 inches
Depth	17 inches
Weight	10 pounds
Power	1 watt

The Service Module provides a means of mixing and diluting solutions without contamination of the cabin atmosphere.

3.1.1.1.1 Colorimeter Chemistry - To support the Colorimeter Module, the Service Module shall perform the following functions:

A. Mix selected sample volumes of 15 µl, 50 µl, and 100 µl, into 3.4 ml of water, This shall be accomplished in the Colorimeter Module sample/reagent containers.

B. Mix 15 µl sample volumes in 3.4 ml normal saline. This shall be accomplished in the Colorimeter Module sample/reagent containers.

3.1.1.1.2 Blood Cell Counter - To support the Blood Cell Counter Module, the Service Module shall perform the following functions:

A. Mix 15 μl of whole blood into 3.4 ml normal saline. This shall be accomplished in the WBC sample bag (reference Blood Cell Counter Module specification).

B. Mix 15 μl of the above mix into 3.4 ml normal saline. This shall be accomplished in the RBC sample bag (reference Blood Cell Counter Module specification).

3.1.1.1.3 Rinse Water - The Service Module shall supply rinse water for the Blood Cell Counter Module, Electrode Module, Hematocrit Module, Slide Stainer Module, and other clean-up functions.

3.1.1.1.4 Vacuum - The Service Module shall provide a vacuum port and valve on the front panel.

3.1.1.2 Secondary Performance Characteristics

3.1.1.2.1 Sample Dilutions - The method of mixing solutions shall be based on conventional pipetter diluter techniques.

3.1.1.2.1.1 Sample Measurement - The sample shall be drawn from the sample container into the diluter with a positive displacement position. For the water dilution, three volumes shall be provided: 15 μl, 50 μl, and 100 μl. The design shall provide for a means of selecting these volumes from the front panel. For the saline dilution, only 15 μl samples shall be drawn.

3.1.1.2.1.2 Sample Mixing - The μl sample shall be ejected into a flexible container by being flushed out of the diluter with the measured 3.4 ml of solution. The 3.4 ml diluting solution shall be delivered by a positive displacement piston.

3.1.1.2.1.3 Sample Container/Diluter Interface - The transfer of sample to the diluter to the flexible container shall be accomplished without contamination of the cabin atmosphere. The sample and diluent shall be injected into the flexible containers by penetration of a septum in the container by a needle on the diluter.

3.1.1.2.2 Rinse Water - The rinse water shall be transferred from the Service Module to the desired location by a retractable hose. The water shall be dispensed by a manually-operated pump on the end of the hose. The volume of water dispensed per pump stroke shall be approximately 1/2 ml.

3.1.1.2.3 Vacuum System - The Service Module shall provide a source of vacuum at the front panel. The vacuum shall be available through a female Luer-Lok. The vacuum shall be operated by a manually-operated spring-return valve.

3.1.1.2.3.1 Vacuum System Liquid Trap - To prevent contamination of the vacuum source, Service Module vacuum sysaem design shall provide a liquid trap. The design shall provide for positive indications when the trap requires maintenance.

3.1.1.2.3.1 Vacuum Source - The vacuum source shall be the spacecraft's vacuum system. The Service Module design shall give positive indication when gas is flowing into the main vacuum source, either by operation of the control valve or accidental leak in the module system.

3.1.2 Operability - Per attached General Requirements which apply to all Procurement Specifications.

PROCUREMENT SPECIFICATION

RADIOISOTOPE COUNTER

1.0 SCOPE

This specification establishes the requirements for performance of one Radioisotope Counter. This unit is required to measure plasma volume, red blood cell mass, and red blood cell survival using a radioisotope tracer technique.

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics

3.1.1.1 Primary Performance Characteristics - Tracer materials used are radioiodinated human serum albumin (RISA) labeled with 125-iodine, and sodium chromate labeled with 51-chromium. A well-crystal photomultiplier radioisotope counter is used with a single channel analyzer output. Front panel switches are used to select photomultiplier voltage, amplification gain, single channel output baseline and window, at preset time. Radioisotope counter display is through the Biochemical Station control and display console.

Measurement reproducibility using the unit will be equivalent to that achieved in present, properly conducted, clinical radioisotope laboratories, or $\pm$ 5% for the plasma volume and RBC mass determinations. The minimum feasible radiation dose to the subject is a design requirement. Other requirements include system flexibility, simplicity of operation, safety, and minimization of system weight, volume and power requirements.

3.1.2 Operability - Per attached General Requirements which apply to all Procurement Specifications.

PROCUREMENT SPECIFICATION

SPECIMEN MASS MEASUREMENT DEVICE

1.0 SCOPE

This specification establishes the requirements for the performance of a Specimen Mass Measurement Device (SMMD).

For purposes of the Mineral Balance, Bone Desitometry and Bioassy of Body Fluids Experiments, it is necessary to measure the mass of such items as bags of food, beverage containers, and containers of urine or feces.

A Specimen Mass Measurement Device (SMMD) which is easy to use, accurate, small, lightweight and requires very little electric power, is required to perform these measurements.

The SMMD is needed to determine the mass of small items in the range of 1 to 500 grams in a one g environment and 1 to 1000 grams in a zero g environment. The principle of the device is based on the fact that a spring-mass system having one degree of freedom will oscillate at a frequency which is a function of the mass. Therefore, by measuring the frequency (or the period) of oscillation of a calibrated spring-mass device, one can determine the mass of the specimen.

The SMMD shall be similar to the unit described in the following NASA documents:

MSC-KW-E-69-10 (P)	End Item Spec-Flight Hardware for Specimen Mass Measurement (Experiment M074)	5-23-69
MSC-KW-E-69-11	Experiment Requirements Document for SMMD	9-69
13M12091	Experiment M074 SMM-Flight AAP-2 Mechanical Requirements - Prelim.	4-1-69
13M12092	AAP Payload Integration-Interface Control Doc. Exper. M074 SMMD. Flight AAP-2 Electrical Requirements.	4-1-69

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics - The SSMD shall consist of a clamping container for the specimen, which is spring-mounted on a rigidly fixed base. When the specimen container is started into oscillatory motion a photo cell beam shall be interrupted by a shutter blade attached to the carriage and picked up by a photo sensitive transistor. The output of the transistor shall be a 5 v 1 ms nominal width pulse train.

3.1.1.1 Primary Performance Characteristics - Mass of small objects in the range of 1 to 500 grams in a one-g artificial gravity environment and 1 to 1000 grams in a zero-g environment shall be determined. Duration of the actual measurement shall be less than 20 seconds. Measurements shall be made while the spacecraft is quiescent, (e.g., rotational rate shall not exceed 10 degrees per hour about any axis).

In a one-g artificial gravity environment the SMMD shall be set upon a fixture that permits horizontal leveling. The SMMD shall be mounted upright so that its oscillation vector is perpendicular to the spacecraft's centrifugal vector.

The SMMD will be stowed at the central measurement station. IMSC will provide dimensional interface requirements. Provision shall also be made to rigidly mount the SMMD in its deployed configuration in a location which is convenient for its intended use, and where it can be connected to the IMBLMS Station by an 8-ft. electrical cable.

Provision shall be made to connect a power and signal cable assembly to the SMMD +28 v DC ($^{+2}_{-4}$VDC) input power lines and +5 v DC output signal lines plus a shield are required. Connectors for the SMMD and Cable Assembly shall be interchangeable with that of the Body Mass Measurement Device (BMMD).

Locking controls, cocking lever, and a release trigger are required. No displays are required.

Removal from launch stowed position, installation in measurement position, and operation shall be accomplished by a single crewmember. Trial operations will be at the discretion of the operator. One hand operation shall be required. A level platform shall be provided for pre-installation checkout of the SMMD and for operation under 1 g artificial gravity.

Five graduated calibration masses shall be provided. Two food bags, each having a mass between 100 and 150 grams, shall also be provided for calibration and checkout purposes.

Size stowed:	6 x 10 x 8 inch max.
Size deployed:	6 x 10 x 14 inches max.
Weight:	6 pounds max.
Power required:	4 watts average, +28 v DC
Controls:	A locking control to secure all moving parts
	A rear level to cock the oscillating part.
	A release trigger.

3.1.2 Operability - Per attached General Requirements which apply to all Procurement Specifications.

PROCUREMENT SPECIFICATION

TOTAL BODY WATER

1.0 SCOPE

This specification establishes the requirements for performance of one Total Body Water (TBW) unit. This unit is required to study the dynamics of dehydration under space flight conditions.

TBW is determined using a tracer that distributes uniformly throughout the body's water and that can be measured conveniently. Ethanol is used as the tracer and gas chromatograph detection.

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics

3.1.1.1 Primary Performance Characteristics - Tracers for use in TBW determination must mix uniformly with both extracellular and intracellular water and be measurable at high accuracy at high dilutions. The reference ethanol dosage of 0.28 gm/kg is recommended. Ethanol is metabolized in a matter of hours by the body, therefore it is necessary to obtain tracer concentration at 20 minute increments over a four-hour period and back-extrapolate to time zero to determine concentration. Measurement reproducibility shall be ± 10%.

3.1.1.2 Secondary Performance Characteristics - The TBW measurement system shall include the ethanol-water dose containers for the subjects, saliva collection vials, a centrifuge (supplied by the Biochemical Station) for saliva separation, the Gas Chromatograph detector, syringes for the Gas Chromatograph sample injection, and calibration solutions. The dose containers each hold 20 gm of ethanol diluted to 100 ml total volume with distilled water. Two calibration solutions shall be provided. One contains 0.3 mg/ml of ethanol and the other contains 0.03 mg/ml water.

The Gas Chromatograph shall use a thermal conductivity detector and a column that separates ethanol ahead of water. Estimated

C-2

sensitivity of this detector is 0.3 μg of ethanol. Gas Chromatograph detector output shall go to a peak integrator which is present to respond to the timing of the ethanol delution time. The integrated output is then converted to the equivalent ethanol concentration, which is displayed at the Biochemical Station. The Gas Chromatograph unit shall have the following characteristics: Weight 10 lb, 6 x 6 x 8 in., and power consumption of 13 watts.

3.1.2 Operability - Per attached General Requirements which apply to all Procurement Specifications.

PROCUREMENT SPECIFICATION

VISION TESTER

1.0 SCOPE

This specification establishes the requirements for the performance and design of a self-contained Vision Tester providing a comprehensive series of visual tests which can be administered by the subject, without the need for another individual in attendance.

2.0 APPLICABLE DOCUMENTS

Applicable documentation for manned spacecraft equipment as listed in Appendix A shall be used as guidelines; exact listing to be specified in accordance with final mission constraints.

3.0 REQUIREMENTS

3.1 Performance

3.1.1 Performance Characteristics - The Vision Tester shall be an entirely self-contained and self-administering device to test nine different aspects of the subject's vision; including, Critical fusion frequency, depth perception, phorias, color perception, photostress, dark adaption, brightness threshold, visual acuity and visual field. Procedures and directions to the subject shall be provided external to the Vision Tester; data collection and reduction shall also be performed externally. In all modes of operation, external displays shall derive information from the Vision Tester via an interface defined herein. The processing required to perform the tests shall be done internally. Appendix 1 lists the output data requirements.

3.1.1.1 Primary Performance Characteristics - The equipment contained within the Vision Tester shall have the detailed performance and functional characteristics defined below; refer to Figure 1, Vision Tester Block Diagram.

3.1.1.1.1 Design - The Vision Tester Electronics shall be designed to provide multiple usage from its component subsystems; design goal for the Vision Tester shall be to perform as many of the tests as possible with the same delay circuits, fixation lamps, mirrors, etc. The Vision Tester Electronics shall contain sufficient processing capacity to perform the adaptive tests with the subject, and to provide data for displays of current test results on internal displays, or to external (not included) system displays. An external data system will be used solely for storage and tabulation of test results.

Several of the vision tests have a general characteristic in common: they require the presentation of a stimulus, and monitoring of the subject's response to that stimulus, in order to either measure some parameter of the eye, or to monitor the subject's response to a repeated stimulus in order to determine a rate of change or to establish a threshold. In either case the test is to be performed automatically under control of the Vision Tester Electronics. It shall be a design goal to perform these similar tasks with a minimum of equipment.

3.1.1.1.2 Operating Instructions and Test Results - In its primary mode of operation, via a central data handling system, operating instructions and instant recall of test results in a display format will be placed on the external systems display equipment. In its back-up mode minimum displays will be provided by an external (not included) LED numerical readout.

3.1.1.1.3 Description of Required Vision Tests

a) Critical Fusion Frequency - This test measures the frequency above which the presented stimulus appears to be "fused" and below which the stimulus appears to be flickering. Adaptation, fixation, brightness, and other variables must be held under strict control in order to achieve a valid measure of CFF. Measurement is made in one eye only. For data handling purposes there are to be 5 test repeats; right eye only. For each repeat only the critical fusion frequency (-40 Hz) needs to be outputted; represented by an analog value between 0 - 5 vdc and/or a 10 bit digital word.

b) Depth Perception - The test is to be incorporated in the vision tester and shall be based on the measurement of binocular disparity. The technique to be implemented shall use a miniaturized, far-optics, Howard-Dolman rod system. In this test the subject will align two rods (by means of one moveable rod) so that the moveable rod appears at the same distance as a fixed rod. For data handling purposes, the test shall be repeated three times. For each trial a measure of the angular disparity must be outputted; represented by an analog value between 0 - 5 vdc and/or a 10 bit digital word.

c) Phorias - Phorias are deviations of the eye from a coincident line of regard. They are normally evidenced when the stimulus

to fusion is weak or absent. The test for phorias shall consist of presenting separate stimuli to each eye under low illumination, and measuring the deviation of the two eyes line of regard. Phorias are the result of muscle imbalance. They may be horizontal, vertical, or both. The test shall consist of a Maddox rod, which is a glass which causes a small source of light to appear as a vertical or horizontal streak, and a Wrisley prism, which is two prisms sandwiched apex to base. The Maddox rod shall be presented to one eye, the Wrisley prism to the other. One eye sees a line, the other a point light source. Any perceived misalignment is then corrected by rotating one of the prisms against the other. The degree of refractive correction can then be read off the rotated prism. For data handling purposes, an analog value between 0 - 5 vdc, or a 10 bit digital word must be transferred to the data management system for each of the four tests (horizontal, vertical, near, far).

d) Color Perception - The vision test for color perception shall be performed using an anomaloscope. The subject shall be presented with a bisected field, the lower half monochromatic yellow and the upper half a mixture of monochromatic red and monochromatic green. The mixture shall be under control of the subject. He will adjust the red/green mixture until he is satisfied that it "matches" the yellow. For data handling purposes, an analog value between 0 - 5 vdc or a 10 bit digital word shall represent color mixture (Rayleigh number).

e) Photostress - The test shall measure the eye's recovery from glare. It shall be carried out by presenting the dark-adapted eye with a sudden, brief, high intensity flash of light. A test patch shall then be presented. Time to recover sensitivity enough to report the test patch is measured. The test is performed monocularly, right eye only. The procedure is repeated three times and each recovery time output. For data handling purposes, an analog value between 0 - 5 vdc or a 10 bit digital word, shall represent recovery times.

f) Dark Adaptation - This test shall provide a measure of the rate at which the subject dark adapts, i.e., a measure of the rate which the sensitivity of his visual system adjusts to a reduction of the prevailing luminance level to a condition of darkness. The significant

portion of this adaptation occurs over a period of 20-30 minutes. The test shall consist of presenting the subject with visual field (after a period of light adaptation) which contains a red fixation point and a test patch whose brightness is decreased slowly. The minimum detectable value of the test patch is noted. On the next trial the starting intensity is reduced and brightness is gradually decreased in preparation for another measurement. The successive brightness levels thus obtained constitute, when plotted as a function of time, a measure of the subjects' dark adaptation rate. For data handling purposes the test is performed one time, right eye only, and two analog outputs between 0 - 5 vdc, or 10 bit digital words shall represent time and brightness.

g) Birghtness Threshold - Minimum brightness threshold shall be measured as the last stable value of the dark adaptation test. As such it shall measure the absolute threshold of brightness perception of a dark adapted subject. For data handling purposes an analog voltage between 0 - 5 vdc, or a 10 bit digital word, shall represent the threshold level.

h) Visual Acuity - This test shall measure the minimum visually perceptible break, or offset, in a line in minutes of visual arc. Acuity is defined as the reciprocal of this just resolvable visual angle. The test shall be administered by the subject's measuring a vernier displacement of images. For data handling purposes during the displaced image test the smallest angular displacement represented by an analog voltage between 0 - 5 vdc, or a 10 bit digital word, in each diminishing series shall be noted. Repeat 5 times. Both eyes shall be tested monocularly, each at both near and far.

i) Visual Field-Perimetry - This test shall prepare a retinographic map of visual perception or non-perception. Mapping shall be performed to determine the boundaries of the visual field, and to discover areas of non-perception. The maps shall be made by moving some visible stimulus target along a meridian from the perimeter to center while the subject fixates the center point of the meridian. The subject reports appearance and/or disappearance of the object. This is done for twelve principal meridians passing through the same center point, each rotated

15° from the next and the results mapped separately for each eye. Color fields shall be mapped as well as white. For data handling during the visual field test, the test shall include 2 eyes, 7 colors, 24 meridian radii and provide 336 radius measurements. (For each, up to 3 field boundaries must be noted with an analog level between 0 - 5 vdc or a 10 bit digital word.)

3.1.1.1.4 Back-Up Mode - In the back-up mode of operation it shall be possible for the Vision Tester to be completely self-contained and self-administering and to provide sufficient displays on an external numerical readout to allow the subject to keep track of his own test results with no connection to a processor. It will be necessary, for certain tests, to have an observer gather data in addition to the subject's data acquisition.

3.1.1.1.5 Equipment Definition - The Vision Tester shall be constructed in three major sections. A control and response panel which shall contain all necessary input and output devices with which the subject and the vision tester communicate. The vision tester optics which shall contain all the optical and mechanical elements associated with the individual measurements. Weight of the tester optics shall not exceed 50 pounds; with 30 pounds as a design goal. the vision tester electronics which shall be remotely located (up to 30 feet) from the remaining visual test apparatus and shall occupy a volume of no more than 2 cubic feet.

3.1.1.1.6 Input Power - Input power to the Vision Tester will be 120/208 volts, 3 phase, 400 Hz.

3.1.1.1.7 Calibration of Light Output - One or more photosensors shall be provided in the Vision Tester optics to allow calibration of the lights used for threshold and color perception tests. The output of these sensors shall be used to control the lamp driving voltage.

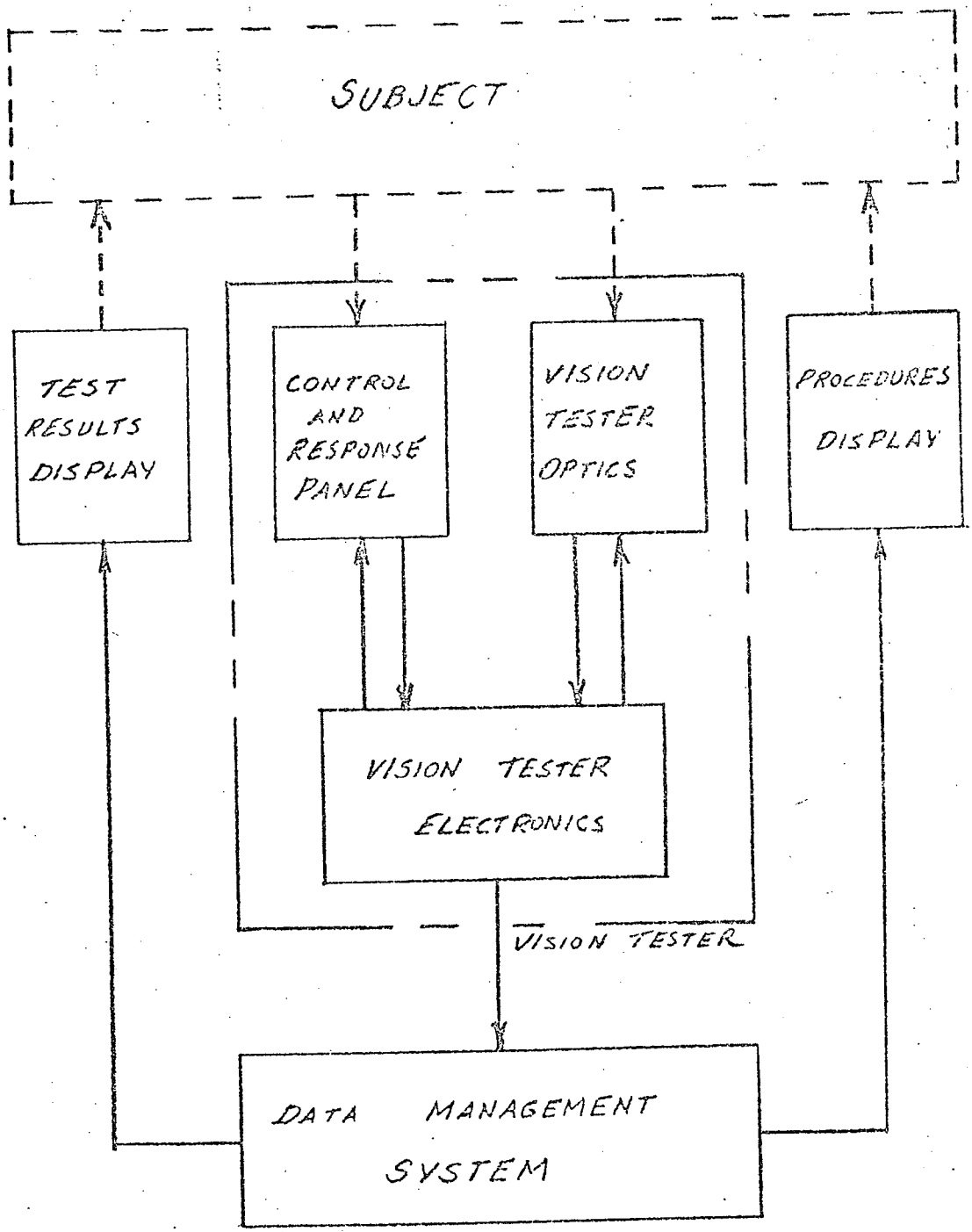
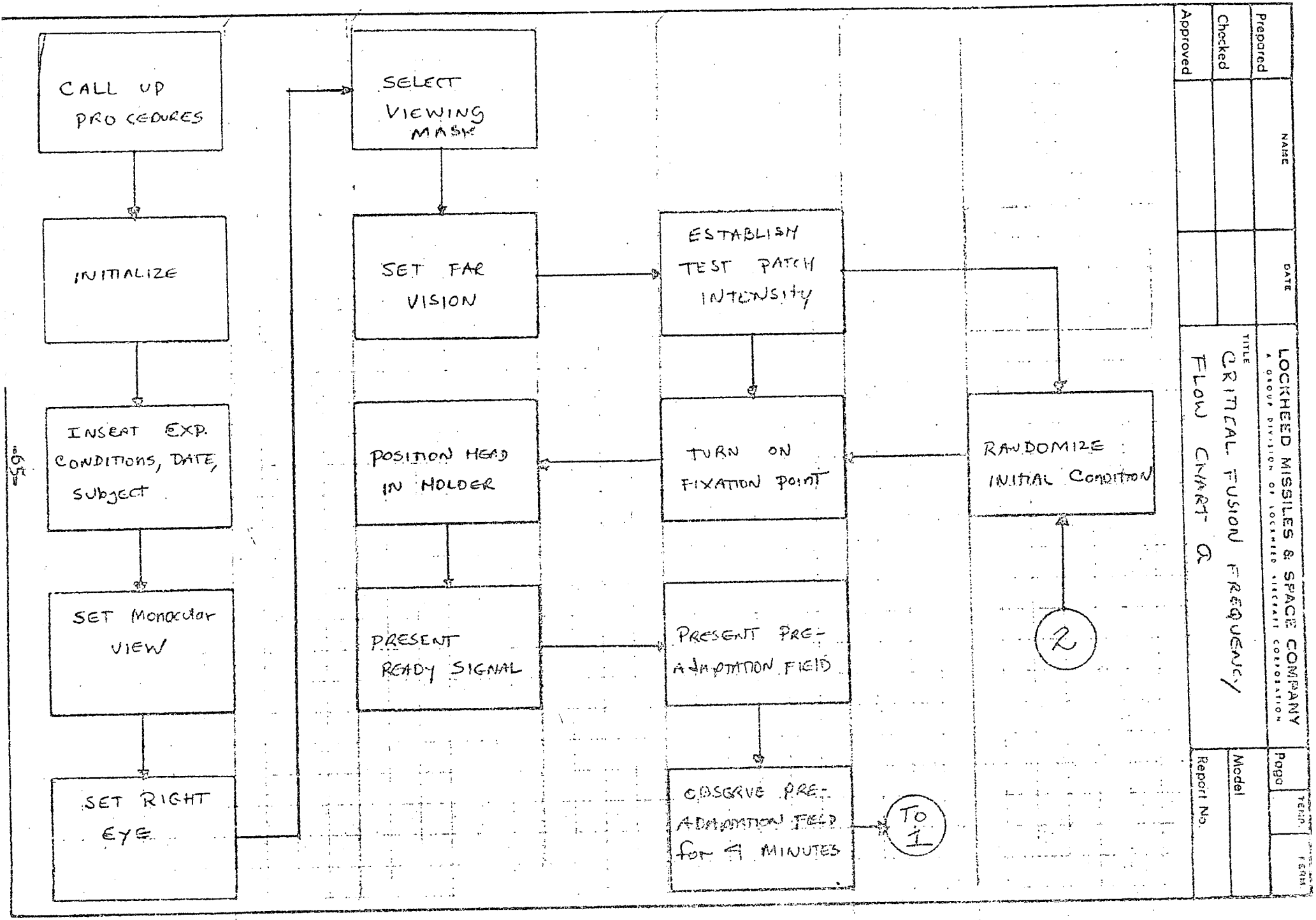
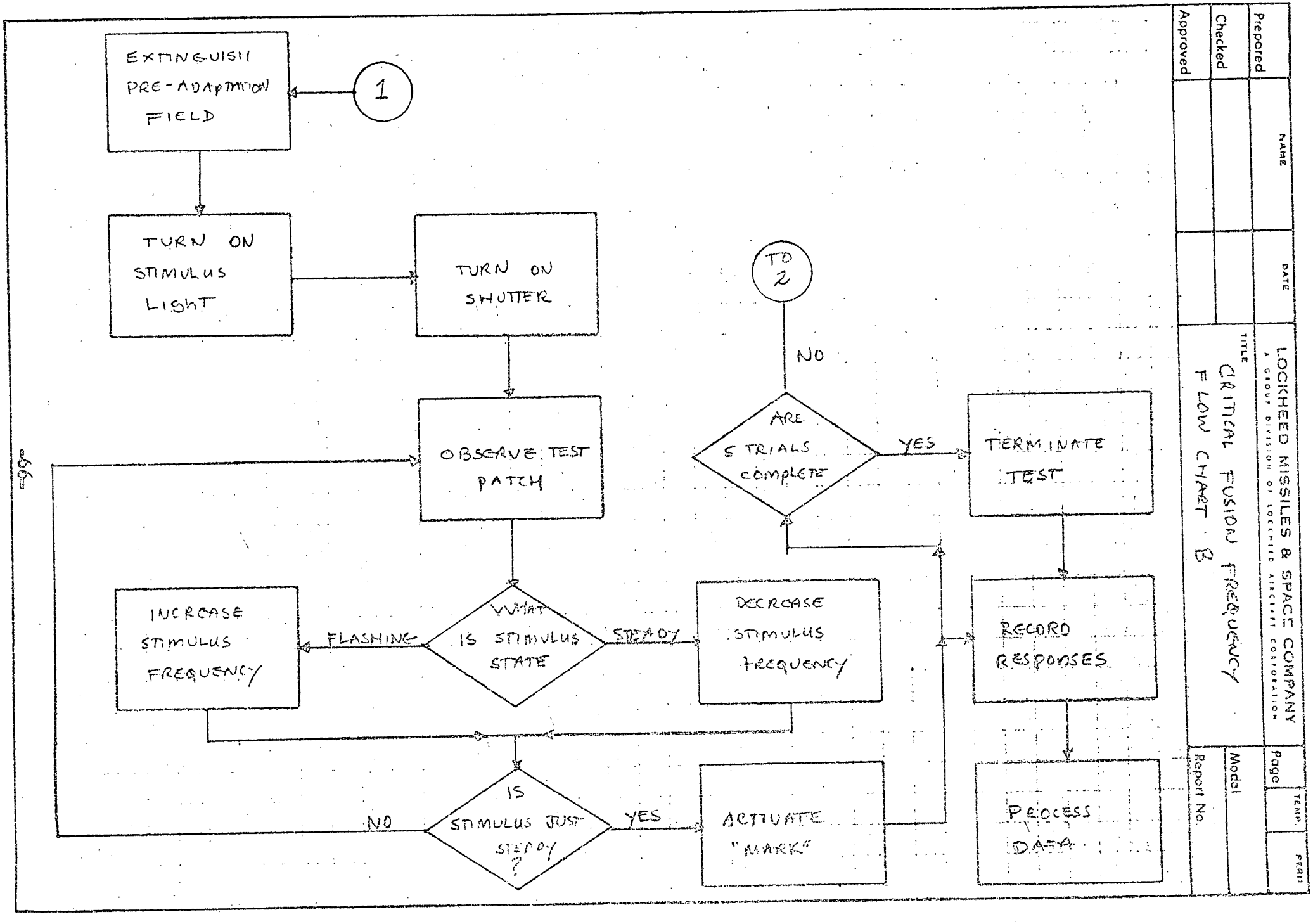


FIGURE 1 — VISION TESTER BLOCK DIAGRAM


CALL UP PROCEDURES
INITIALIZE
INSERT EXP. CONDITIONS, DATE, SUBJECT
SET Monocular VIEW
SET RIGHT EYE
SELECT VIEWING MASK
SET FAR VISION
POSITION HEAD IN HOLDER
PRESENT READY SIGNAL
ESTABLISH TEST PATCH INTENSITY
TURN ON FIXATION POINT
PRESENT PRE-ADAPTATION FIELD
OBSERVE PRE-ADAPTATION FIELD for 4 MINUTES
To 1
RANDOMIZE INITIAL CONDITION
2
Prepared
Checked
Approved
NAME
DATE
LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
TITLE
CRITICAL FUSION FREQUENCY
FLOW CHART A
Model
Report No.
Page
TEMP.
FORM
65


EXTINGUISH PRE-ADAPTATION FIELD
1
TURN ON STIMULUS LIGHT
TURN ON SHUTTER
TO 2
NO
OBSERVE TEST PATCH
ARE 5 TRIALS COMPLETE
YES
TERMINATE TEST
INCREASE STIMULUS FREQUENCY
FLASHING
WHAT IS STIMULUS STATE
STEADY
DECREASE STIMULUS FREQUENCY
RECORD RESPONSES
IS STIMULUS JUST STEADY ?
NO
YES
ACTUATE "MARK"
PROCESS DATA
Prepared
Checked
Approved
NAME
DATE
LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
TITLE
CRITICAL FUSION FREQUENCY
FLOW CHART B
Model
Report No.
Page
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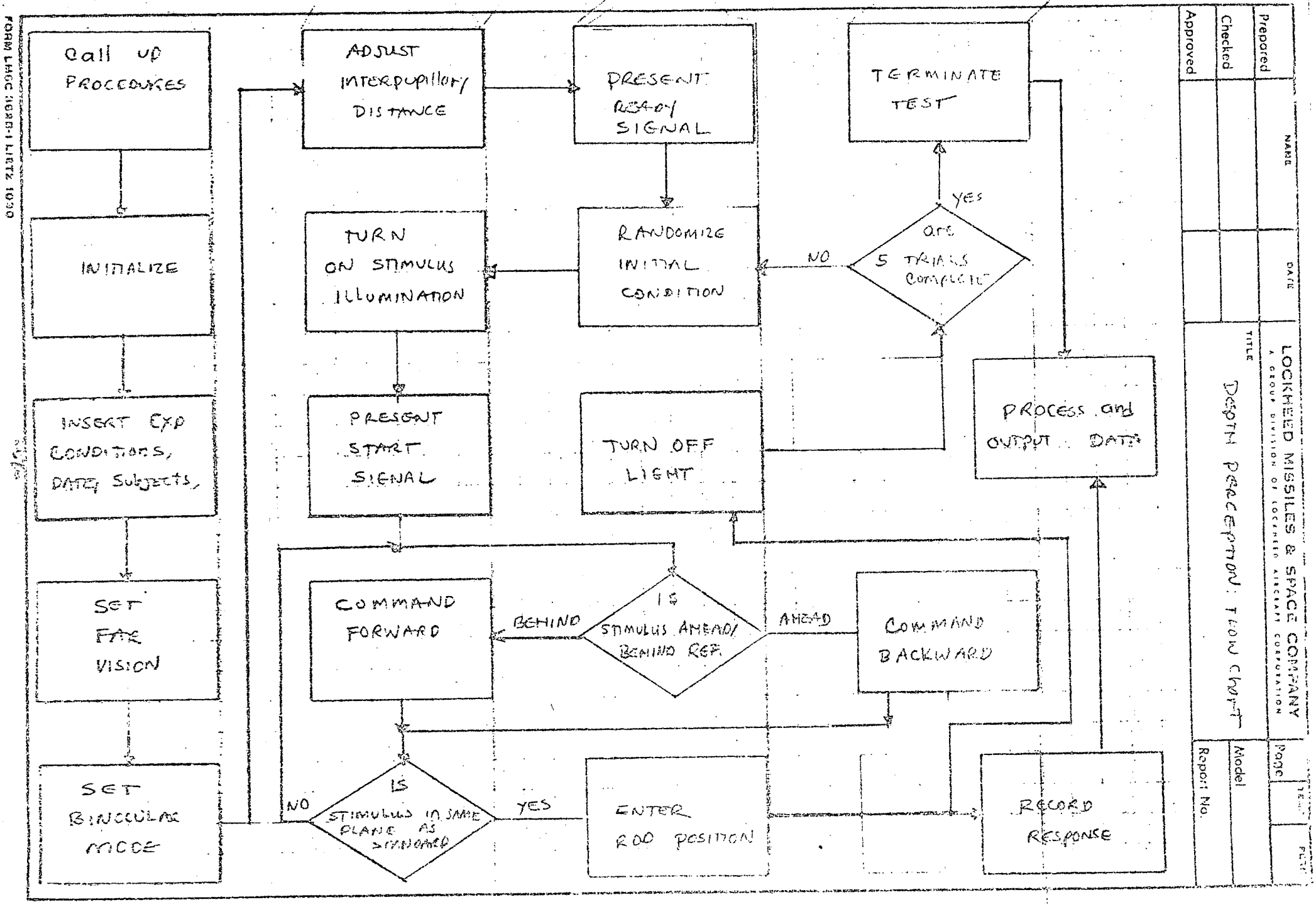
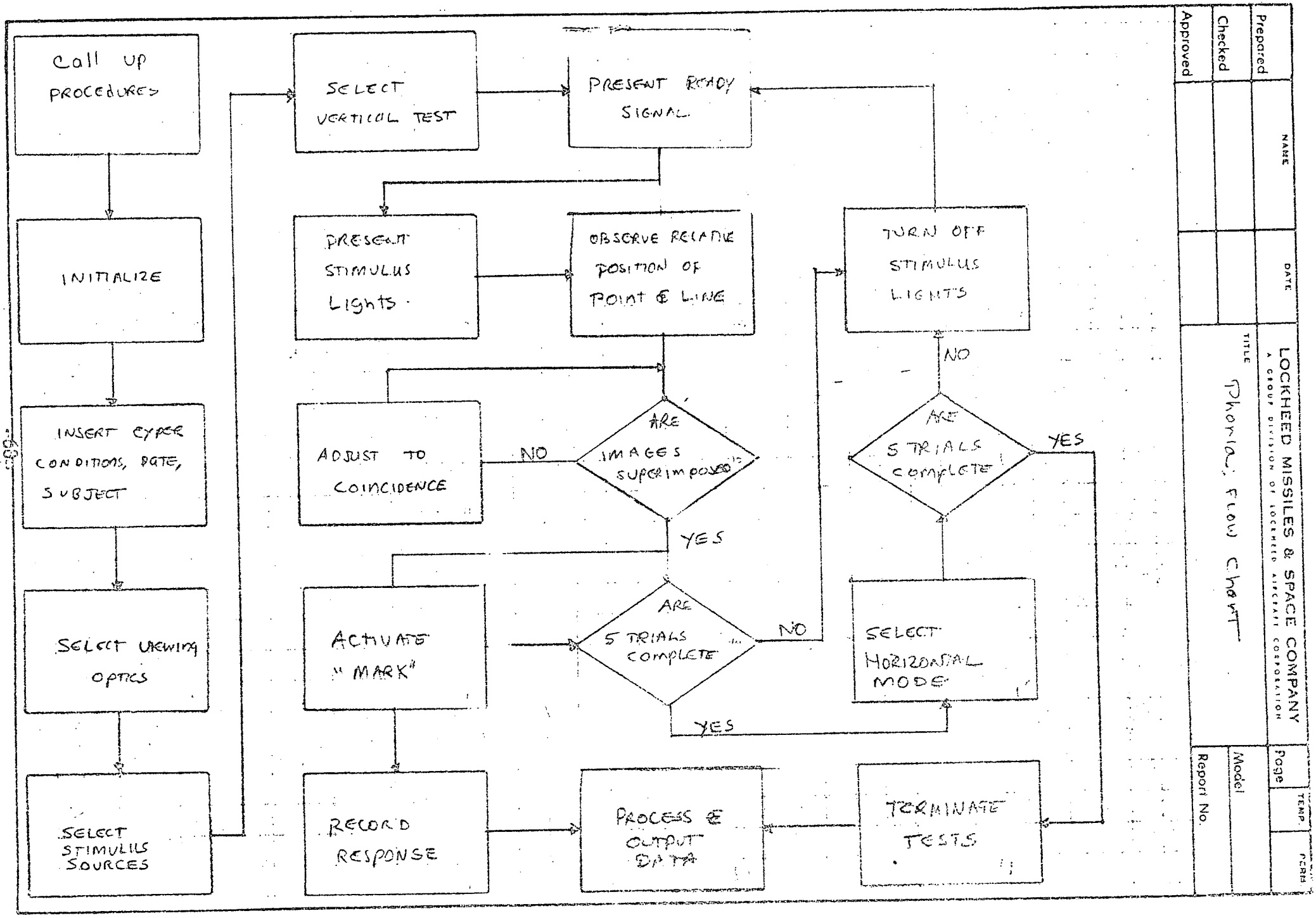
PERT


Call up Procedures
INITALIZE
INSERT Exp Conditions, DATE, Subjects,
SET FAE VISION
SET BINOCULAR MODE
ADJUST INTERPUPILLARY DISTANCE
PRESENT READY SIGNAL
RANDOMIZE INITIAL CONDITION
TURN ON STIMULUS ILLUMINATION
PRESENT START SIGNAL
TURN OFF LIGHT
ENTER ROD POSITION
RECORD RESPONSE
PROCESS and OUTPUT DATA
TERMINATE TEST
ARE 5 TRIALS COMPLETE
YES
NO
IS STIMULUS AHEAD/BEHIND REF
BEHIND
AHEAD
COMMAND FORWARD
COMMAND BACKWARD
IS STIMULUS IN SAME PLANE AS STANDARD
NO
YES
Prepared
Checked
Approved
NAME
DATE
LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
TITLE
DEPTH PERCEPTION: FLOW CHART
Model
Report No.
Page
FORM LMSC 1680-1 LIETZ 1030


Call up PROCEDURES
INITIALIZE
INSERT CYPER CONDITIONS, DATE, SUBJECT
SELECT VIEWING OPTICS
SELECT STIMULUS SOURCES
SELECT VERTICAL TEST
PRESENT READY SIGNAL
PRESENT STIMULUS LIGHTS
OBSERVE RELATIVE POSITION OF POINT & LINE
ADJUST TO COINCIDENCE
ARE IMAGES SUPERIMPOSED
NO
YES
ACTIVATE "MARK"
ARE 5 TRIALS COMPLETE
NO
YES
RECORD RESPONSE
PROCESS & OUTPUT DATA
TURN OFF STIMULUS LIGHTS
NO
ARE 5 TRIALS COMPLETE
YES
SELECT HORIZONTAL MODE
TERMINATE TESTS
Approved
Checked
Prepared
NAME
DATE
TITLE
Phoria, Flow Chart
LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
Model
Report No.
Page
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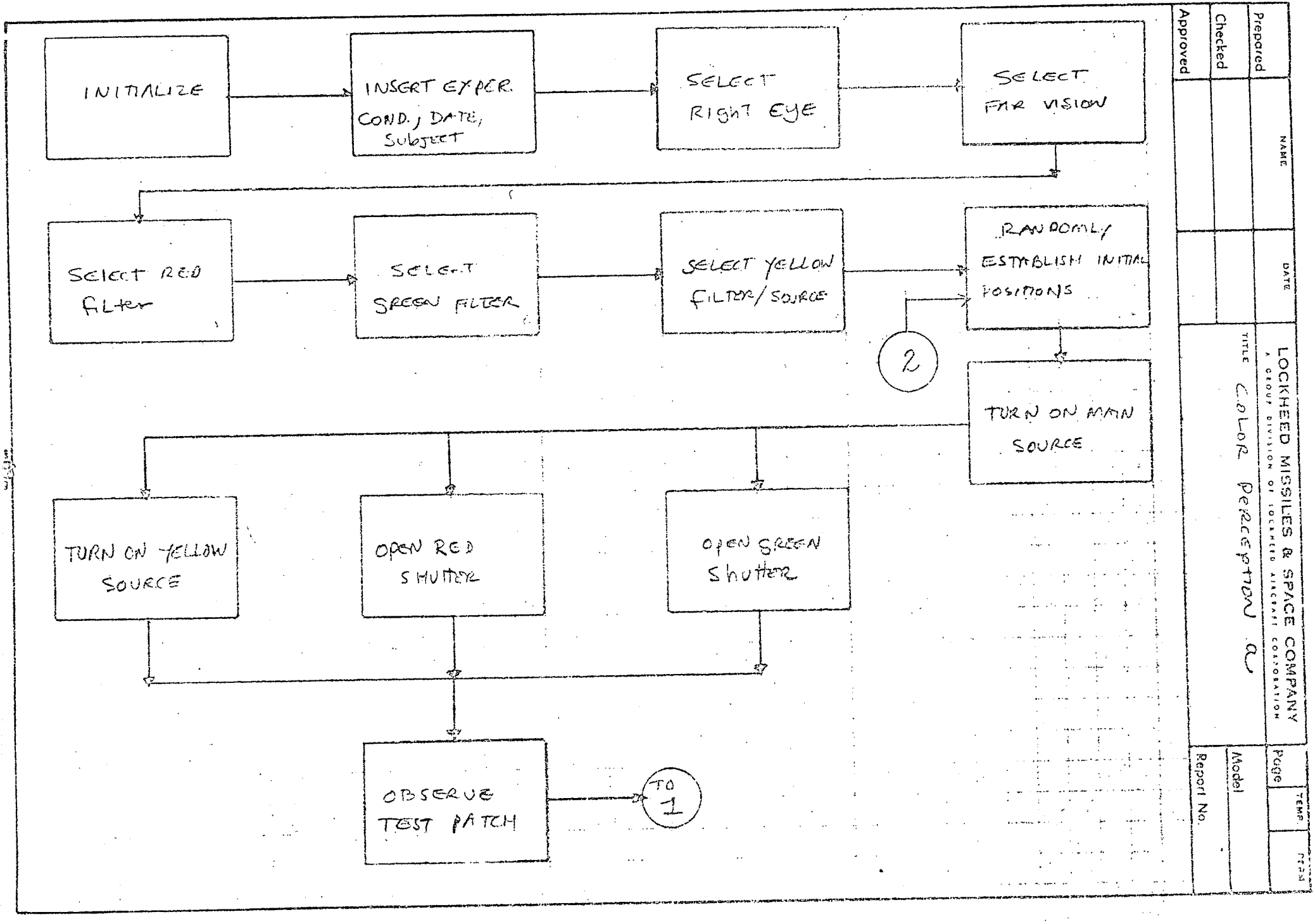
INITIALIZE
INSERT EXPER. COND., DATE, SUBJECT
SELECT RIGHT EYE
SELECT FAR VISION
SELECT RED FILTER
SELECT SCREEN FILTER
SELECT YELLOW FILTER/SOURCE
RANDOMLY ESTABLISH INITIAL POSITIONS
2
TURN ON MAIN SOURCE
TURN ON YELLOW SOURCE
OPEN RED SHUTTER
OPEN SCREEN SHUTTER
OBSERVE TEST PATCH
TO 1
Approved
Checked
Prepared
NAME
DATE
LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
TITLE COLOR PERCEPTION a
Model
Report No.
Page
TEMP
FT PM

Prepared | NAME | DATE | LOCKHEED MISSILES & SPACE COMPANY, A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

Checked

Approved

TITLE Color Projection (b)

Model

Report No.

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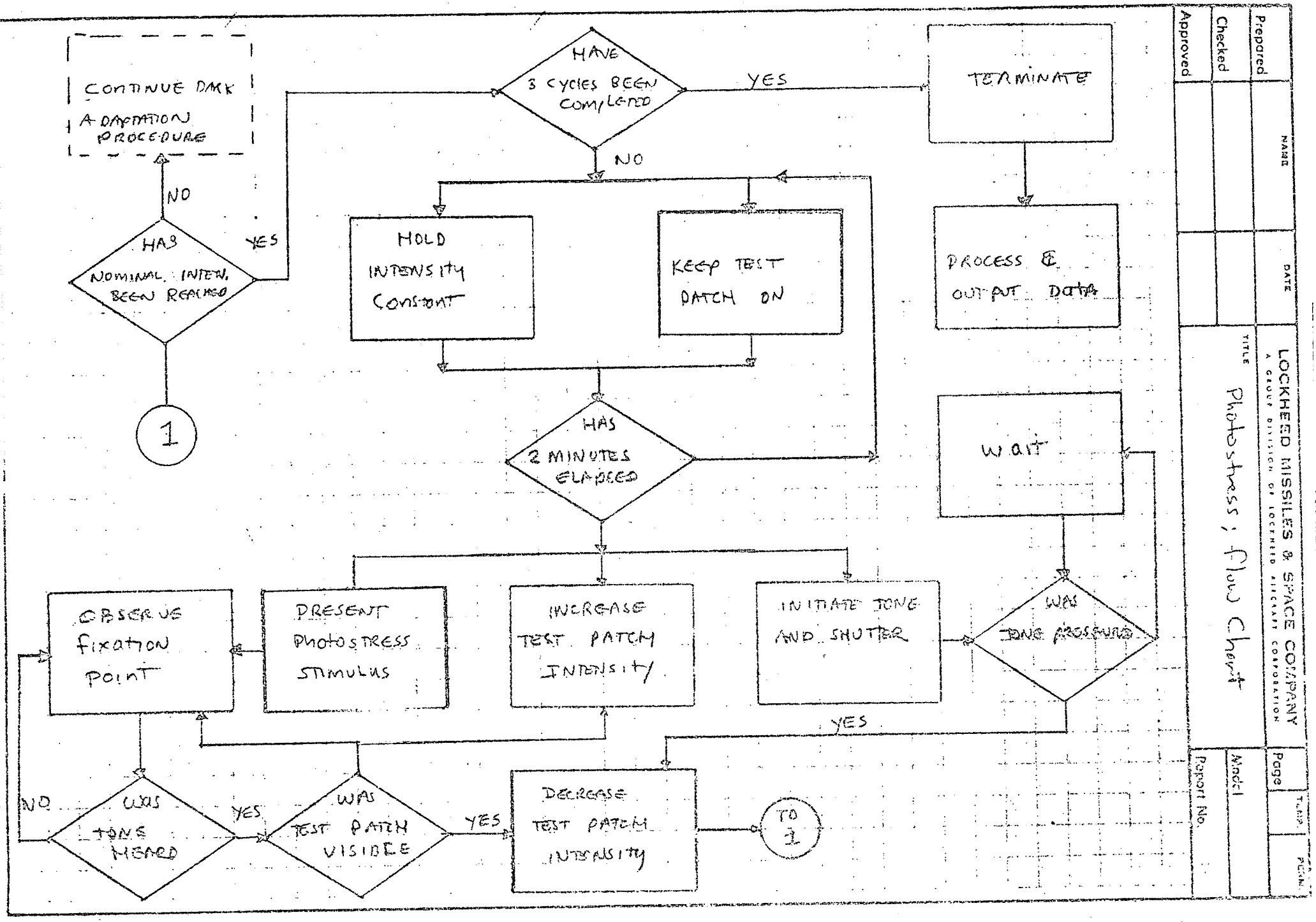
CONTINUE DARK ADAPTATION PROCEDURE
NO
HAS NOMINAL INTEN. BEEN REACHED
YES
1
HAVE 3 CYCLES BEEN COMPLETED
YES
NO
TERMINATE
HOLD INTENSITY CONSTANT
KEEP TEST PATCH ON
PROCESS & OUTPUT DATA
HAS 2 MINUTES ELAPSED
WAIT
OBSERVE fixation POINT
PRESENT PHOTOSTRESS STIMULUS
INCREASE TEST PATCH INTENSITY
INITIATE TONE AND SHUTTER
WAS TONE PRESENTED
WAS TEST PATCH VISIBLE
DECREASE TEST PATCH INTENSITY
TO 1
NO
YES
YES
YES
Prepared
Checked
Approved
NAME
DATE
LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
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Photostress; flow Chart
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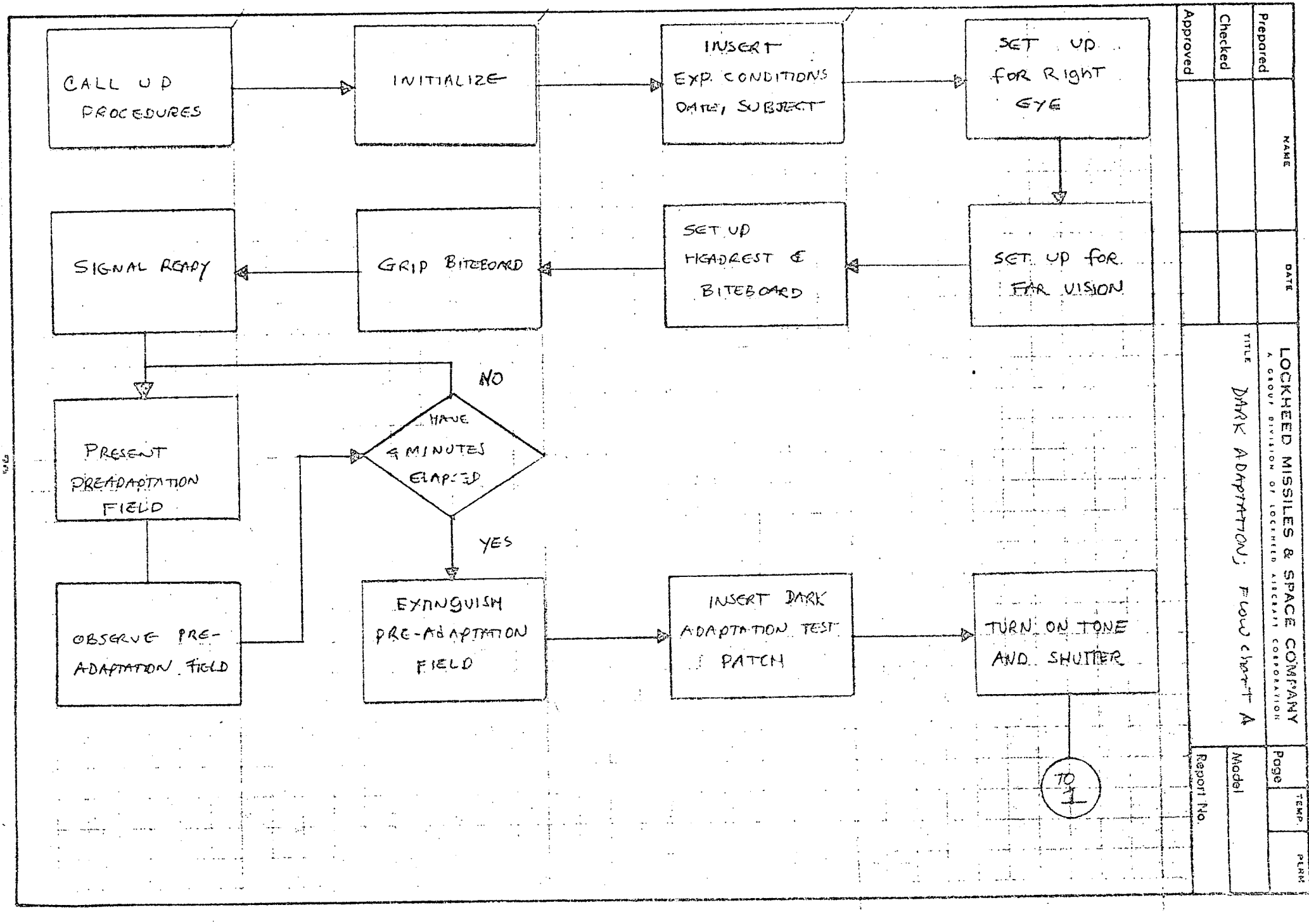
CALL UP PROCEDURES
INITIALIZE
INSERT EXP. CONDITIONS DATE, SUBJECT
SET UP FOR RIGHT EYE
SET UP FOR FAR VISION
SET UP HEADREST & BITEBOARD
GRIP BITEBOARD
SIGNAL READY
PRESENT PREADAPTATION FIELD
HAVE 4 MINUTES ELAPSED
NO
YES
OBSERVE PRE-ADAPTATION FIELD
EXTINGUISH PRE-ADAPTATION FIELD
INSERT DARK ADAPTATION TEST PATCH
TURN ON TONE AND SHUTTER
TO 1
Prepared
Checked
Approved
NAME
DATE
LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
TITLE DARK ADAPTATION FLOW CHART A
Report No.
Model
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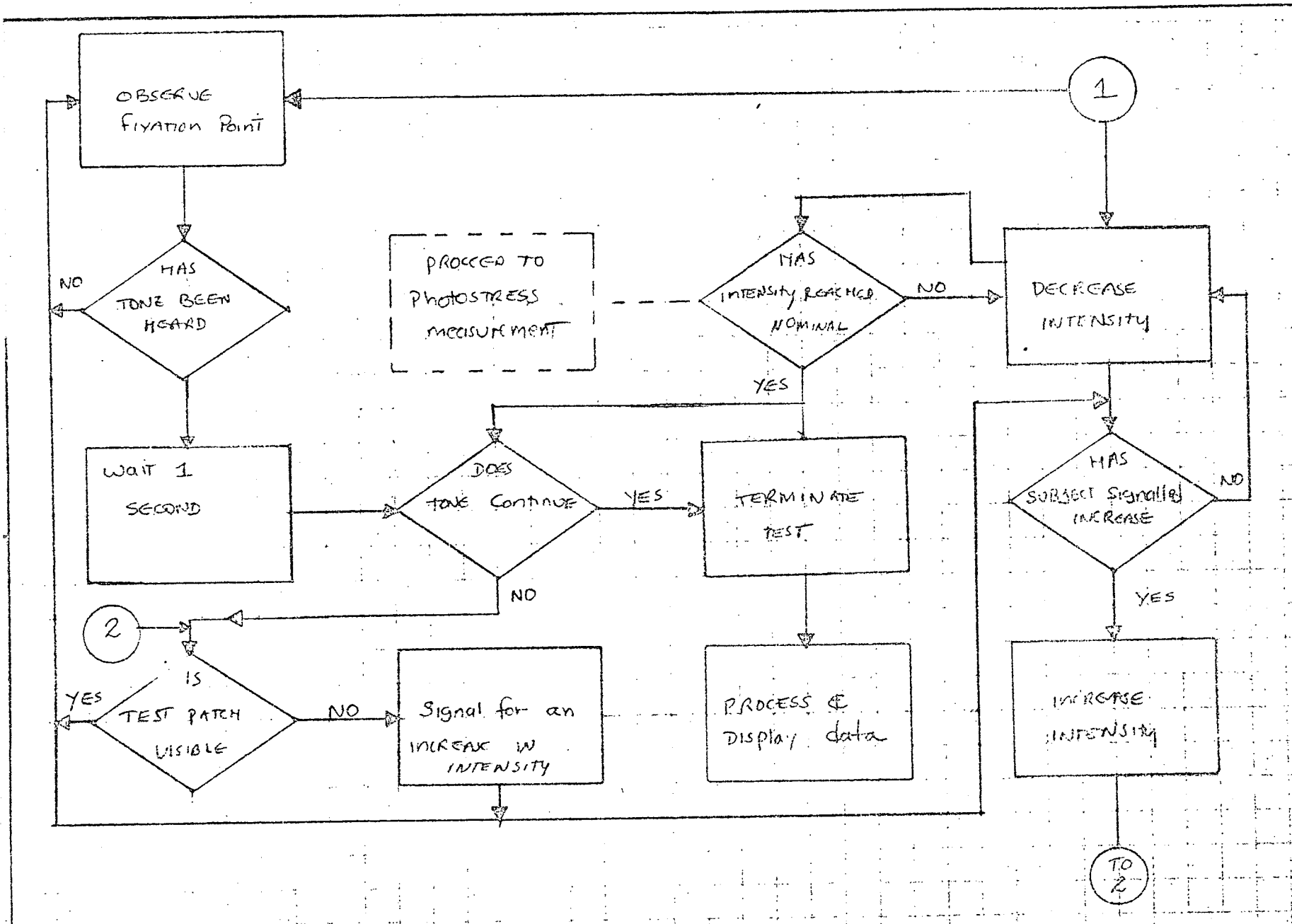
TEMP.
PERM.



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Approved

LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

TITLE DARK Adaptation, FLOW CHARTS

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Model

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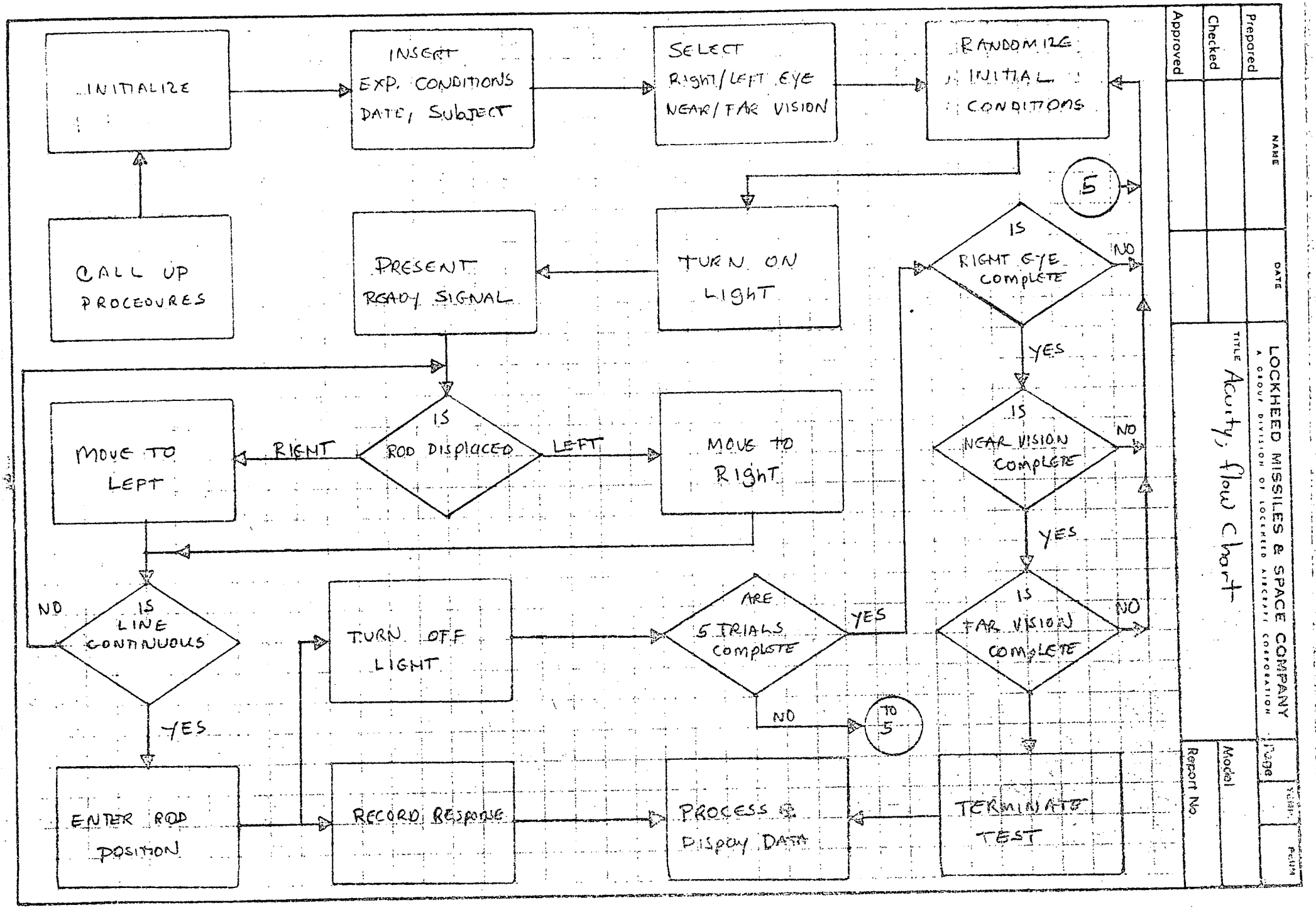
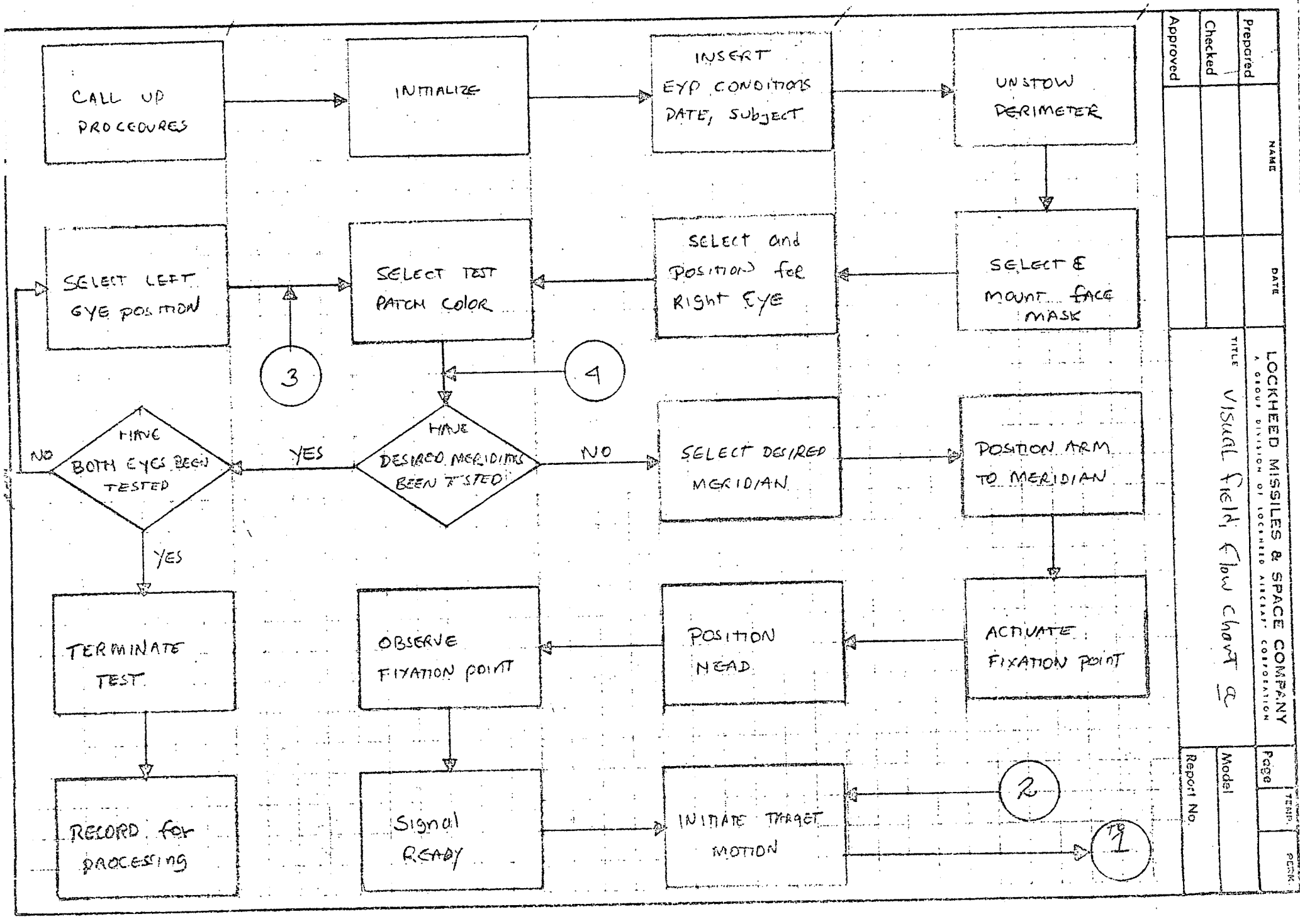

INITIALIZE
INSERT EXP. CONDITIONS DATE, SUBJECT
SELECT RIGHT/LEFT EYE NEAR/FAR VISION
RANDOMIZE INITIAL CONDITIONS
5
CALL UP PROCEDURES
PRESENT READY SIGNAL
TURN ON LIGHT
IS RIGHT EYE COMPLETE
NO
YES
MOVE TO LEFT
RIGHT
IS ROD DISPLACED
LEFT
MOVE TO RIGHT
IS NEAR VISION COMPLETE
NO
YES
NO
IS LINE CONTINUOUS
TURN OFF LIGHT
ARE 5 TRIALS COMPLETE
YES
IS FAR VISION COMPLETE
NO
NO
TO 5
YES
ENTER ROD POSITION
RECORD RESPONSE
PROCESS & DISPLAY DATA
TERMINATE TEST
Prepared
Checked
Approved
NAME
DATE
LOCKHEED MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
TITLE Acuity, flow Chart
Model
Report No.
Page
YEAR
PLAN


CALL UP PROCEDURES
INITIALIZE
INSERT EYE CONDITIONS DATE, Subject
UNSTOW PERIMETER
SELECT LEFT EYE POSITION
SELECT TEST PATCH COLOR
SELECT and POSITION for RIGHT EYE
SELECT & MOUNT FACE MASK
3
4
HAVE BOTH EYES BEEN TESTED
NO
YES
HAVE DESIRED MERIDIANS BEEN TESTED
YES
NO
SELECT DESIRED MERIDIAN
POSITION ARM TO MERIDIAN
TERMINATE TEST
OBSERVE FIXATION POINT
POSITION HEAD
ACTUATE FIXATION POINT
RECORD for PROCESSING
Signal READY
INITIATE TARGET MOTION
2
1
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TITLE Visual Field Flow Chart
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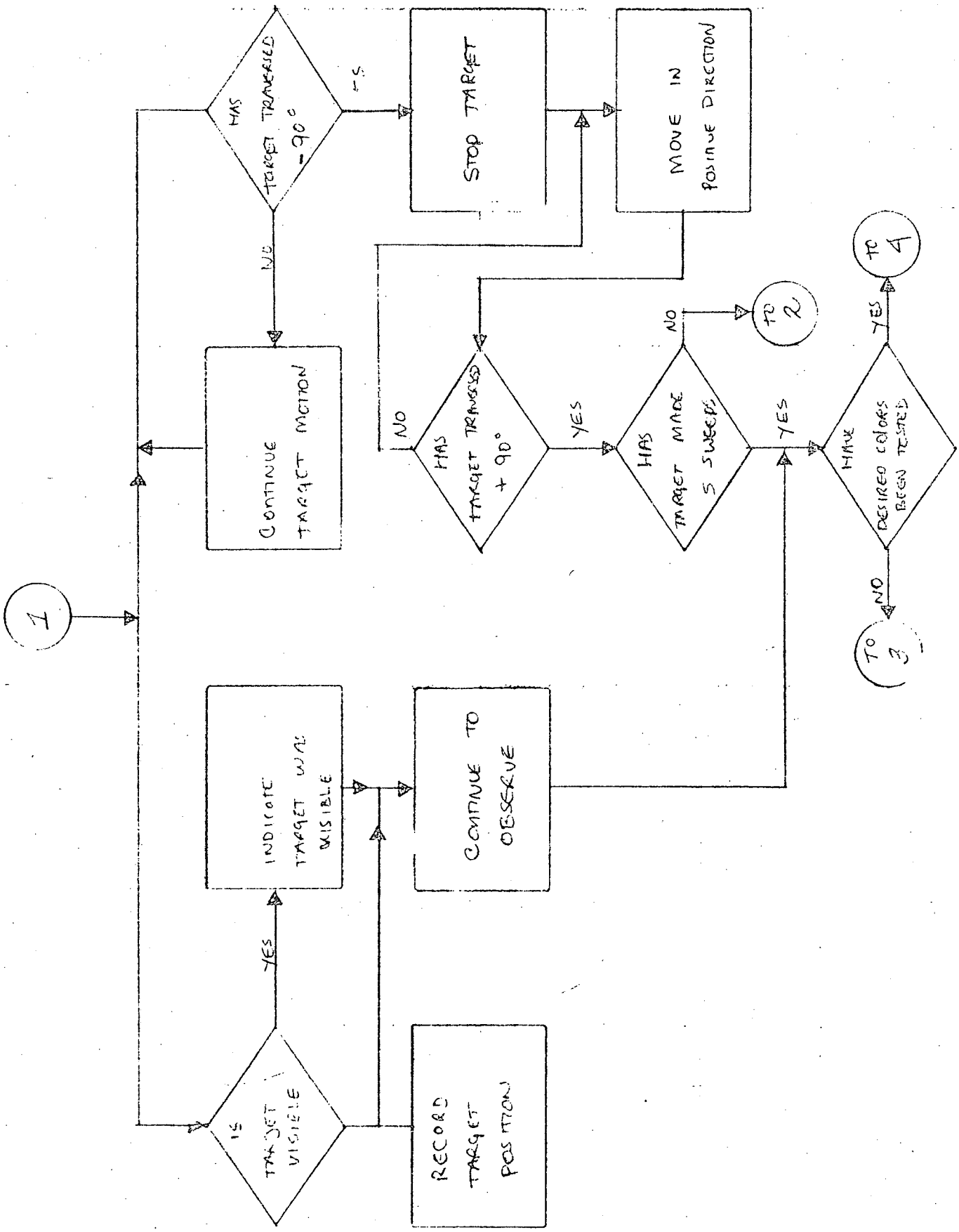

APPENDIX 1

DATA TO BE TRANSFERRED TO OR PROVIDED
BY AN EXTERNAL DATA MANAGEMENT SYSTEM

Critical Fusion Frequency

Processor Modes

- o CFF
- o History, last 3

Back-up Mode

CFF

Depth Perception

Processor Modes

- o Visual Angle corresponding to the distance of the fixed rod
- o Visual angle corresponding to the selected distance of the movable rod
- o Difference angle between above
- o History of this subjects last three difference angles
- o Difference of the difference angles

Back-up Mode

Visual angles

Phorias

Processor Modes

- o Horizontal and Vertical Phorias, in prism diopters, near vision and far vision
- o History, last 3
- o Differences

Back-up Mode

Prism diopters

Color Perception

Processor Modes

- o Rayleigh number (log of the ratio of red intensity to green intensity).
- o History, last 3
- o Differences

Back-up Mode

Rayleigh number

Photo Stress

Processor Modes

- o Time to recover
- o History, last 3
- o Differences

Back-up Mode

Time to recover.

Dark Adaptation

Processor Modes

- o Curve of dark adaptation, log intensity in millilamberts against time in minutes, for approximately 12 minutes (see attached graph)
- o Break point, in log I ml vs time
- o History, past 3 curves
- o Difference, in log I ml vs time

Back-up Mode

Data to generate curve (requires someone other than subject to gather data).

Brightness Threshold

Processor Modes

- o Log I in ml vs time
- o History, past 3
- o Difference etc.

Back-Up Mode

Data to generate curve. (Requires someone other than subject to gather data).

Acuity

Processor Modes

- o Least perceptible acuity, measured as reciprocal of visual angle, each eye, near and far vision
- o History, last 3
- o Differences

Back-Up Mode

Least perceptible acuity

Visual Field Perimetry

Processor Modes

- Complete polar coordinate visual field map, both eyes, 12 meridians zero to 90° peripherally, to nearest 5 degrees (see attached sample map). Maps for white and 6 colors (perimeters, not colors).
- History, last three maps, superimposed.
- Difference, by polar coordinate.

Back-up Mode

Polar coordinate data

3.1.2 Operability, General Requirements

3.1.2.1 Reliability - Components shall be designed with the goal of providing failure-free operation throughout their service life. Based upon a consideration of replacement of failed modules and the availability of on-orbit maintenance, the equipment shall have a minimum probability of successful operation of two years.

3.1.2.2 Maintainability - The equipment shall be designed to provide accessibility consistent with efficient testing, service and maintenance during all phases of prelaunch and operational activities. When the components become inoperable they shall be returned to operation within a time period as short as practicable.

Note: Maintenance and repair cycles, and service and access requirements will be determined early in the next contract phase, as the basic design is established.

3.1.2.3 Useful Life - The equipment shall have a useful life of at least ten years, although resupply and replacement or substitute components will be available every 70 to 90 days. The design of the equipment shall allow extension of its useful life by use of spaceborne modifications. On-board maintenance is acceptable for obtaining the useful life.

3.1.2.3.1 Shelf Life - The equipment shall have a minimum shelf life of three years under normal warehouse conditions. Any limited-calendar life items shall be identified and replacement assured, when required, by the station operating procedures.

3.1.2.3.2 Operating Life - Any limited-operating-life items shall be identified and on-time replacement, recalibration, or adjustments assured, when required, by the station operating procedures.

3.1.2.3.3 Emergency Non-Operating Life - The equipment shall be capable of surviving an emergency 48-hour period under high-vacuum conditions aboard the space station.

3.1.2.4 Natural Environments - The equipment and its components shall withstand the maximum natural environments specified in Table I.

3.1.2.5 Transportability - The packaged equipment shall be capable of being transported by air or motor carrier. Components which are determined to be sensitive to shock or acceleration shall be accompanied by instruments that record acceleration along three orthogonal axes, or the sensitive axes,

with respect to time. The instruments shall be attached directly to the hardware article or to the container, in proximity to the hardware article, to verify that design acceleration limits have not been exceeded during shipment. Packaging of components shall conform to the requirements of NASA Document NMI-6410.1.

3.1.2.6 Human Performance - The equipment shall be designed to ensure safe and efficient operation by ground and flight personnel within the constraints and influences imposed by the operating environments, such as: zero gravity and effects on manipulatory tasks, translation, equipment set-up and operation, unstowage of equipment; partial gravity as it affects equipment tasks under conditions of coriolis forces; task development as related to time limitations, and availability of on-line equipment. The equipment shall conform to the human engineering design criteria specified in MIL-STD-1472 and in Table II,as applicable. The equipment shall maximize the operator and maintainance effectiveness, minimize the personnel skill and training requirements, ensure the effectiveness of personnel/equipment combinations through proper design of equipment, workspace envelopes, and operating procedures, and exhibit design standardization among system elements.

3.1.2.7 Safety - The equipment shall be designed to eliminate or reduce Safety Catastrophic hazards, and eliminate, control, or reduce Safety Critical hazards.

Design compliance shall be in accordance with the applicable safety criteria in the following documents. (Specific application relating to individual designs will be determined early in the next contract phase):

OMSF Safety Program Directive #1A
"System Safety Requirements for Manned Space Flight"

OMSF Safety Program Directive #2
"Safety Guidelines for Certification of Personnel Involved in Hazardous Operation"

NHB 1700.1, Vol. I
"Basic Safety Requirements"

MSCM 1700
"MSC Safety Manual, Part 7 - Man Rating Requirements"

MSC-A-D-66-3

"Procedures and Requirements for the Evaluation of Spacecraft Non-Metallic Materials"

MSC-NA-D-68-1D

"Non-Metallic Materials Guidelines"

MSCI 8825.2

"Operational Readiness Inspections of Facilities and Equipments Involving Man in a Vacuum or Oxygen-rich Environment"

MSCI 1860.1A

"Radiological Control-Exposure of Astronauts to Ionizing Radiation"

AFSC DH 1-6

"Design Handbook for System Safety"

The specific safety requirements specified in the subparagraphs which follow are mandatory.

3.1.2.7.1 Personnel/Hardware Contact - Equipment shall be designed to prevent personnel contact with high temperature surfaces and electrical shock sources. Sharp edges and protuberances shall not be permitted.

3.1.2.7.2 Safeguards - The equipment shall have adequate safeguards to prevent hazardous condition during normal and inadvertant separation. Normal operations, malfunctions, failures and component replacement shall not cause damage to other equipment or injury to personnel. Minimum hazards will be the criteria used in selecting subsystems and component parts.

3.1.2.7.3 Environmental Operation - The equipment shall be designed to operate in all environments (including ionizing radiation) involved in development, testing, and flight without exposing ground or flight personnel to hazards.

3.1.2.7.4 Personnel Hazards - Equipment which may contact personnel or which may contact electrically conductive equipment in contact with personnel must be equipped with current limiting devices sufficient to prevent a current of 5 milliamperes or more from passing through a resistance of 500 ohms; the nominal resistance of the human body.

3.1.2.7.5 Electro-Shock Protection - The equipment shall provide protection against electro-shock by limiting current in any ground return path connected directly to any personnel to less than 100 microamperes in the event that the person should contact a dangerous potential. The equipment shall be designed to provide this protection for voltages up to 150 vac rms or 200 volts peak, over the frequency range of DC to 200 KHz.

3.1.2.7.6 Equipment Containers - All equipment contained in modules shall be provided with sufficient screen-covered holes in the structure, or relief valves, so that in cases of rapid decompression the air inside the module shall not be evacuated at a rate slower than the air outside the module.

3.1.2.7.7 Protection of Exposed Electrical Circuits - Disconnected electrical circuits shall be protected against short circuiting or compromising of other circuits.

3.1.2.7.8 Controls - Switch cover guards shall be designed so that the position of the switch can be determined without moving the cover guard.

3.1.2.7.9 Circuit Protection - All electronics and electrical circuitry shall be protected against excess current flow by means of fuses or circuit breakers.

3.1.2.7.10 Flammability of Wiring Insulation - Insulation used in wiring anywhere within the equipment shall not be capable of sustaining combustion in closed environment atmosphere after removal of the source of ignition or following melting of the electrical conductor by high currents such as those resulting from short circuits or circuit breaker failures. Insulation on conductors subjected to these high currents shall not be capable of igniting the insulation on either conductors which may be in contact with it. This requirement does not apply to wiring which is completely isolated from the closed environment by potting or hermetic sealing.

3.1.2.7.11 Flammability of Wiring Materials and Accessories - Materials and accessories associated with wiring, such as potting, bundle ties, bundle chafe guards, heat shrinkable tubing, solder sleeves, cable clamps, and bundle identification tags that are in contact with electrical wire bundles, shall meet the flammability requirements imposed on electrical

wire insulation by MSC Design and Procedural Standard No. 22, "Flammability of Wiring Insulation."

3.1.2.7.12 Toxicity of Wire Insulation, Ties, Identification Marks and Protective Covering - No materials shall be used for wire insulation, ties, identification marks and protective covering on wiring which will generate toxic fumes in a concentration sufficient to impair crew safety when exposed to a short circuit resulting in the melting of a single wire at a single point of highest resistance.

3.1.2.7.13 Toxicity of Materials - The equipment shall not incorporate materials which, when operating at temperatures up to the maximum anticipated in a mission, will generate toxic or noxious fumes, or dust, in such concentration as to impair crew performance or safety.

3.1.2.7.14 Toxicity of Fluids - Fluids which can produce toxic fumes shall not be used in the equipment if a substitute with equivalent performance exists. Where no satisfactory substitute for the fluid exists, tests shall be performed to assure that the total leakage is less than the concentration which would result in a level of toxicity which would impair personnel safety in a closed environment.

3.1.2.8 Induced Environments - The equipment and its components shall withstand the maximum prelaunch, launch, ascent and orbital environments specified in Table I. The equipment shall not be required to operate except during the manned orbital phases of flight and subsequent to the prelaunch, launch and ascent environments. During orbital operation, the equipment shall withstand only the normal environment in its operating condition; the emergency or inactive mode shall be when the vehicle is inactivated or in an emergency shut-down condition and no operation shall be required.

TABLE I

IMBLMS Design Requirements

Environmental Factors	Ground	Launch/Ascent (Non-Operating)	Orbital
Natural: (Non-Operating)			
Air Temperature (°F)	-15 to 115	TBD	TBD Non-Operating 48 Hr Emergency
Pressure (PSIA)	13.1 to 15.2	14.7 ± 0.3	10^{-8}
Humidity (% RH)	0 to 100	0 to 100	N/A
Salt Spray	N/A	N/A	N/A
Ozone (ppm - 5 years)	N/A	N/A	N/A
Fungi	N/A	N/A	N/A
Radiation (REM/year)	N/A	N/A	TBD
Micrometeriods	N/A	N/A	N/A
Induced:			
Acceleration:			
Longitudinal (Steady State & Dynamic)	N/A (Protectively packaged)	lateral 3 g axial 3 g forward 5 g aft	0 to 1 g at IMBLMS when rotating. 0.035 g max. transients
Shock	N/A (Protectively Packaged)	30 g 11 ms pulse with half-sine pulse per MIL-STD-810B	N/A

TABLE I (Continued)

Environmental Factors	Ground	Launch/Ascent (Non-Operating)	Orbital
Vibration	N/A (Protectively Packaged)	Random 20 - 50 Hz .05 g^2/Hz 50 - 100 Hz 6 db/Oct rise 100 - 500 Hz .2 g^2/Hz 500 - 1000 Hz 6 db/Oct. roll off Overall 15.5 g (rms) 3 min. duration along each of three mutually perpendicular axes. Sin Lateral 5 - 12.5 Hz 0.25 in. DA 12.5 - 400 Hz 2.0 g Axial 5 - 15 Hz 0.25 in. DA 15 - 400 Hz 3.0 g Notes: (1) At primary resonances of the console, reduce input levels to 0.5 g lateral and 1.0 g axial (2) Sweep 3 minutes per octave	N/A

TABLE I (Continued)

Environmental Factors	Ground	Launch/Ascent (Non-Operating)	Orbital
Atmosphere:			
Pressure (PSIA)	10 to 15.2 (Assumed)	14.7 ± 0.3	0 - 14.7 ± 0.3 (10 nominal min. 14.7 nominal)
Composition:			
O_2 (PSIA)	Variable may flush with N_2	Nominal for on-orbit operation or may be N_2 only.	3.1 to 3.5
N_2 (PSIA)			6.9 to 11.7
CO_2 (MMHg)			0 to 7.6 (15 max for 2 Hr 5 nominal)
H_2O (MMHg)			5.0 to 12.0
Contaminants:			
Biological (Ft^3)	N/A	TBD	TBD
Organic (PPM)	N/A	TBD	TBD
Temperature (°F)	60 to 75 (Assumed)	TBD	65 to 75
Humidity (% RH)	0-100 (Assumed)	21 to 76	21 to 76
Acoustics	N/A Protectively Packaged)	140 db overall	N/A

TABLE II

Human Performance Design and Analysis Requirements

Human Factors Requirements	Technical Scope	Specifications and Standards	Related Documents	Data Required and Evaluation Technique
ANTHROPOMETRY	Shirtsleeve Body Dimensions Manual Reach Envelopes Work Station Envelope	MIL-STD-1472 USAF Population Data NASA CR-1206	AFSC DH 1-3	Work Station Drawings Mockup Evaluation
OPERATOR/SUBJECT COORDINATION	Inter-Crew Visibility Safety Monitoring of Subjects Structural Interference	IVELMS Medical Experiment Definitions	MIL-STD-1472	Task Analyses Mockup Evaluation Design Drawings OG Simulation
BODY SUPPORT POSITIONING AND RESTRAINT	Structural Integrity Comfort Provisions Adjustment Features Manual Workspace	MSFC BECMAR Studies NASA SP 6506 GE/SD 67D4441, Vol. III	MIL-STD-1472 AFSCM 80-9, Vol III	Detailed Analysis Design Drawings Mockup Evaluation OG Simulation
OPERATOR/SUBJECT TRANSLATIONAL MOBILITY	Workstation Ingess/Egress Handholds and Rails Structural Interference	MSFC BECMAR Studies NASA SP 6506 GE/SD 67D4441, Vol. III	MIL-STD-1472 NASA CR-1205	Design Drawings Mockup Evaluation OG Simulation
MODULE IDENTIFICATION AND LAYOUT	Marking/Placarding ID Location and Standardization Information Content Sequence of Operation	AFSC DH 1-3 Woodson and Conover	MIL-STD-1472	Task Analyses Design Drawings Mockup Evaluation
DISPLAY/CONTROL SPECIFICATION AND ORGANIZATION	C/D Requirements Types/Quantities/Inter-Operation Sequence/Frequency/Priority Analysis Location/Layout	MSFC-STD-267 Morgan, Cook Chapanis and Lund	MIL-STD-1472 Woodson and Conover	Experiment Definitions Task Analyses Design Drawings Mockup Evaluation

TABLE II (Continued)

Human Factors Requirements	Technical Scope	Specifications and Standards	Related Documents	Data Required and Evaluation Technique
STOWAGE	Experiment Consumables/ Supplies Operator/Subject Equipment Spares/Software Waste Solids/Fluids	MIL-STD-1472	IMBLMS Medical Experiment Definitions Waste Management Subsystem Definition	Task Analyses Design Drawings Mockup Evaluation
MAINTAINABILITY	Visual and Manual Access Requirements Fault Identification/ Isolation Calibration/Servicing Inflight Replacement	MIL-STD-1472 Woodson and Conover	IMBLMS Maintenance Concept MSFC HECMAR Studies GEMSD 67D4441, Vol AFSCM 80-9, Vol III	Maintenance Requirements and Realibility Analyses Maintenance Task Analyses Drawings/Mockup Eval.
SAFETY	Injury Potential Restraint Impact Protection Mechanical/Electrical/ Chemical/Toxic Hazards	MIL-STD-1472 NASA CR-1205 MIL-STD-882 OMSF Safety Prog. Directive 1	NASA SP 6506 AFSC DH 1-6 KMI 1710.1, Attach A MSCM 1700, Part 7	Task Analyses Design Drawings Mockup Evalution OC Simulation
COMMUNICATIONS	Coordination/Intercommunications Spacecraft/Ground Aided/Unaided Voice	MIL-STD-1472	NASA SP 6506 AFSC DH 1-3	Task Analyses Schematics and Design Drawings Subsystem Test and Evaluation

APPENDIX "A"

PROCUREMENT SPECIFICATIONS

PROJECT AND SYSTEM DOCUMENTS GUIDELINES

SPECIFICATIONS

Military

MIL-V-173B	Varnish, Moisture-and-Fungus-Resistant (for the Treatment of Communication, Electronic and Associated Electrical Equipment)
MIL-B-5087B (1)	Bonding, Electrical and Lightning Protection for Aerospace Systems
MIL-W-6858C Interim Amendment 1	Welding, Resistance: Aluminum, Magnesium, Non-Hardening Steels or Alloys, Nickel Alloys, Heat-Resisting Alloys and Titanium; Spot and Seam
MIL-F-7179D	Finishes and Coatings, General Specification for Protection of Aerospace Weapons Systems, Structures and Parts
MIL-E-8189C	Electronic Equipment, Missiles, Boosters, and Allied Vehicles
MIL-A-9067C	Adhesive Bonding, Process and Inspection Requirements for
MIL-W-22759B Amendment 3 and Supplement 1	Wire, Electrical, Fluorocarbon-Insulated, Copper and Copper Alloy

MIL-C-27500 (with Amendment 4)	Cable, Electrical, Shielding and Unshielded, Aircraft and Missile
MIL-W-24041 (2) (with Notice 2)	Molding and Potting Compound, Chemically Cured, Polyurethene (poly-ether-based)
MIL-M-9368C	Microfilming of Engineering Documents, 35 mm, Requirements for
MIL-C-8638 (6)	Cleaning Compound, Oxygen Systems
NASA	
KSC-SPEC-Q0001	Conformal Coating
MSC-SPEC-C-8	Spacecraft On-Board Equipment, Cleanliness Specification for
MSC-SPEC-Q-1	Crimping of Electrical Connections
MSFC-SPEC-222	Resin Compound, Electrical and Environmental Insulation
MSFC-SPEC-270B	Materials, Component Lead and Interconnection for Welded Electronic Modules
MSEC-SPEC-379B	Compound, Potting and Encapsulating, Silicone
MSFC-SPEC-393	Printed Circuit Board Conformal Coating, Elastomeric
MSFC-SPEC-455	Plastic Sheet, Laminated, Nickel-Iron-Cobalt Clad (for Weldable Printed Wiring)

LMSC	
1421010	Integrated Medical and Behavioral Laboratory Measurement System (IMBLMS) System Specification
STANDARDS	
Federal	
FED-STD-228	Cable and Wire, Insulated, Methods of Testing
Military	
MIL-STD-12C Change Notice 1	Abbreviations for Use on Drawings and in Technical-Type Publications
MIL-STD-100A	Engineering Drawing Practices
MIL-STD-130C	Identification Marking of U.S. Military Property
MIL-STD-143B	Specifications and Standards, Order of Precedence for the Selection of
MIL-STD-410A	Qualification of Inspection Personnel (magnetic Particle and Penetrant)
MIL-STD-453 Change 1	Inspection, Radiographic
MIL-STD-461A (3)	Electromagnetic Interference Characteristics, Requirements for Equipment

MIL-STD-462 (2)	Electromagnetic Interference Characteristics, Measurement of
MIL-STD-701G Change 1	List of Standard Semi-Conductor Devices
MIL-STD-704A Change 1	Electric Power, Aircraft, Characteristics and Utilization of
MIL-STD-810D	Environmental Test Methods
MIL-STD-882	System Safety Program for Systems and Associated Subsystems and Equipment, Requirements for
MIL-STD-883	Test Methods and Procedures for Microelectronics
MIL-STD-889	Dissimilar Metals
MIL-STD-1267B	Leads, Weldable, for Electronic Component Parts
MIL-STD-1313A	Military Standard Microelectronic Terms and Definitions
MIL-STD-1472A	Human Engineering Design Criteria for Military Systems, Equipment and Facilities
MIL-STD-1473	Human Engineering Design Criteria for Space Systems
MS 27253	Plate, Identification

NASA

MSC-STD No. 22	Design and Procedural Standard, Flammability of Wiring Insulation
MSFC-STD-154A	Printed Wiring Boards (Copperclad) Design, Documentation, and Fabrication of
MSFC-STD-267A	Human Engineering, Design Criteria for
MSFC-STD-271	Fabrication of Welded Electronic Modules

OTHER DOCUMENTS

AFETRM 127-1	Range Safety Manual, Air Force Eastern Test Range
AFSC DH 1-3	Design Handbook 1-0, General, Personnel Subsystems
AFSC DH 1-4	Design Handbook, Electromagnetic Compatibility
AFSC DH 1-6	Design handbook on Systems Safety, Items 2C1, 2C2, 2C3
AFSCM 80-9, Vol III	Handbook of Instructions for Aerospace Systems Design, Reduced Gravity
Apollo Program Directive 39	General Standard for Preservation, Packaging, Packing, Handling and Shipping of Apollo Space Vehicle Components, Parts, and Associated Equipment

CR-1205	Compendium of Human Responses to the Aerospace Environment
CR-1206	
D-NA-0002	Procedures and Requirements for Flame and Outgassing of Manned Spacecraft
GEMSD 67 D4441 Volume III	
H4-1	Federal Supply Code for Manufacturers
KMI 1710.1 Attachment A	General Safety Plan, Kennedy Space Center
MIL-HDBK-5A Change 3	Metallic Materials and Elements for Aerospace Vehicle Structures
MSC 02681	Non-Metallic Materials Design Guidelines and Test Data Handbook
MSC-A-D-66-3A	Procedures and Requirements for the Evaluation of Spacecraft Non-metallic Materials
MSC-NA-D-68-1D	Nonmetallic Materials Guidelines
MSCF-PROC-224 with Amendments	Automatic Single Soldering of Printed Circuit Assemblies
MSCI-1860.1A	Radiological Control - Exposure of Astronauts to Ionizing Radiation

MSCI-8825.2	Operational Readiness Inspections of Facilities and Equipments Involving Man in a Vacuum or Oxygen-Rich Environment
MSCM 1700	MSC Safety Manual, Part 7 - Man Rating Requirements
MSCM 5320	Parts Reliability Requirements
MSCM 8080	Manned Spacecraft Criteria and Standards
NHB 1700.1, Vol I	Basic Safety Requirements
NHB 5300.4 (3A)	Quality Requirements for Hand Soldering of Electrical Connections
NHB 6000.1 (1A)	Requirements for Packaging, Handling and Transportation for Aeronautical and Space Systems, Equipment and Associated Componets
NHI 6410.1	Packaging, Preservation and Marking Requirements for Aeronautical and Space End Items, Components, Parts and Associated Equipment
OMSF Safety Program Directive No. 1	System Safety Requirements for Manned Space Flight
OMSF Safety Program Directive No. 2	Safety Guidelines for Certification of Personnel Involved in Hazardous Operations

RA-064-001-1

Apollo CSM and LM Electrical Inspection Criteria

SP 6506